NEW ENGLAND WATER WORKS ASSOCIATION.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

WATER WORKS STATISTICS FOR THE YEAR 1902, IN FORM ADOPTED BY THE NEW ENGLAND WATER WORKS ASSOCIATION.

COMPILED BY CHARLES W. SHERMAN, EDITOR, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

The following tables of statistics contain more or less complete statistics for forty-four water works, which have used, more or less closely, the form adopted by the Association for summarizing statistics. Some of these works report under very few of the headings of the summary.

The Editor has made no attempt to compile statistics from water-works reports which do not include at least a partial summary.

The report of the Committee on Uniform Statistics, containing the form as endorsed for use in the 1901 reports, is printed on page 51 of vol. 15 of the JOURNAL (March, 1902). The page for Financial Statistics was changed by vote of the Association in September, 1902, as reported in the December, 1902, JOURNAL (vol. 16, p. 263). Blank forms for use in preparing summaries are printed by the Association, and will be furnished on request.

Previous compilations of statistics may be found in the JOURNAL, as follows:

Statistics for	*Reference to Journal.*
1886	Vol. I, No. 4, p. 29
1887	Vol. II, No. 4, p. 28
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1901	Vol. XVI, p. 223

In the various tabulations, statistics are given for the following places and years:

Place.	*Year*
1. Albany, N. Y.	1900
2. Andover, Mass.	1900
3. Arlington, Mass.	1900
4. Atlantic City, N. J.	1898, 1900–02
5. Attleboro, Mass.	1894–1902
6. Bay City, Mich.	1886–87, 1893–96, 1900–02
7. Belmont, Mass.	1902
8. Billerica, Mass.	1899–1902
9. Boston, Mass.	1886–94, 1897, 1900
10. Brockton, Mass.	1893–1902
11. Burlington, Vt.	1886–1902
12. Cambridge, Mass.	1900–02
13. Chelsea, Mass.	1900–02
14. Cleveland, Ohio	1902
15. Concord, N. H.	1895, 1898, 1900–02
16. Dover, N. H.	1900
17. Erie, Pa.	1900
18. Essex Junc., Vt.	1900
19. Fall River, Mass.	1886–95, 1897–1902
20. Fitchburg, Mass.	1886–92, 1894–1902
21. Freeport, Me.	1901
22. Geneva, N. Y.	1900
23. Haverhill, Mass.	1900
24. Holyoke, Mass.	1886–92, 1897–98, 1900–02
25. Hull, England	1900
26. Ipswich, Mass.	1900
27. Keene, N. H.	1899–1900
28. Lawrence, Mass.	1902
29. Leicester, Mass.	1900
30. Leominster, Mass.	1900
31. Lewiston, Me.	1900
32. Lowell, Mass.	1886, 1897–1902
33. Lynn, Mass.	1888–98, 1900–02
34. Madison, Wis.	1900, 1902
35. Manchester, N. H.	1900
36. Marlborough, Mass.	1900
37. Maynard, Mass.	1901–02
38. Metropolitan Water Works, Mass.	1900–02
39. Middleboro, Mass.	1895–1902
40. Middletown, Conn.	1902
41. Minneapolis, Minn.	1900–02
42. Nantucket, Mass.	1900

43. Nashua, N. H. 1900
44. New Bedford, Mass. 1886–1902
45. New London, Conn. 1886–1902
46. Newton, Mass. 1888–1902
47. Norwich, Conn. 1901
48. Oberlin, Ohio 1893–1902
49. Plymouth, Mass. 1886–1902
50. Providence, R. I. 1897–1902
51. Quincy, Mass. 1893, 1900–01
52. Reading, Mass. 1893, 1895–1902
53. Reading, Pa. 1901–02
54. St. John, N. B. 1902
55. Salem, Mass. 1900
56. Sandusky, Ohio 1886
57. Schenectady, N. Y. 1886, 1900–01
58. Somerville, Mass. 1900–02
59. Springfield, Mass. 1886–1902
60. Taunton, Mass. 1886–1902
61. Toronto, Canada 1893
62. Trenton, N. J. 1886–87
63. Troy, N. Y. 1886, 1888–93, 1897–99
64. Waltham, Mass. 1886–1902
65. Ware, Mass. 1886, 1888–92, 1900–02
66. Watertown, Mass. 1900
67. Wellesley, Mass. 1888–93, 1898–1902
68. Westerly, R. I. 1902
69. Whitman, Mass. 1897–1902
70. Wilmington, Del. 1900
71. Winchendon, Mass. 1900–02
72. Woburn, Mass. 1900–02
73. Woonsocket, R. I. 1886–1900, 1902
74. Worcester, Mass. 1900
75. Yonkers, N. Y. 1893–96, 1900–02

1902.—TABLE 1.—GENERAL AND PUMPING STATISTICS.

Number.	Name of City or Town.	Date of Construction of Works.	By Whom Owned.	Source of Supply.	Mode of Supply.	1	2:—Description of Fuel Used.				
						Builders of Pumping Machinery.	a Kind.	b Brand of Coal.	c Av. Price per Gross Ton	d Per Cent. of Ash.	e Wood. Price per Cord.
1	Atlantic City, N. J.	1882 1888	City.	Driven & Artesian Wells & Absecon Creek.	Pumping.	Worthington, Gordon-Max'll, d'Auria. Smith-Vaile.	Bituminous.	Standard. Eureka.	$ 3 70	6	...
2	Attleboro, Mass.	1873	Town.	Well near Seven Mile River.	Pumping.	Deane, Barr.	Bituminous.	Georges Cr.	....	...	...
3	Bay City, Mich.	1872	City.	Saginaw Bay.	Pumping.	Holly.	Bituminous.	Slack.	1 65	23	$1 33
4	Belmont, Mass.	1887	Town.	Metropolitan W.W.	.....	.....	...	....	....	...	...
5	Billerica, Mass.	1898	Town.	Driven Wells.	Pumping.	Barr.	Bituminous.	Georges Cr.	4 70	...	...
6	Brockton, Mass.	1880	City.	Salisbury Brook.	Pumping.	Worthington, Holly.	Bituminous.	Georges Cr.	5 15	9	...
7	Burlington, Vt.	1867	City.	Lake Champlain.	Pumping.	Worthington.	Bituminous. Mill Shav'ngs.	Clearfield, Coaldale.	4 05 4 63	...	...
8	Cambridge, Mass.	1855	City.	Hobbs and Stony Brooks, Fresh Pond.	Pumping.	Groshon, Worthington, Blake.	Bituminous.	Cumber-land.	4 30 8 50	...	...
9	Chelsea, Mass.	1867	City.	Metropolitan W.W.	.....	.....	..	....	....	...	...
10	Cleveland, Ohio.	1856	City.	Lake Erie.	Pumping.	Worthington, Knowles, Allis, Holly, Kilby.	Bituminous.	Slack.	1 74 1 42	..	...
11	Concord, N. H.	1872	City.	Penacook Lake.	Gravity and Pumping.	.....	...	....	.....	...	...
12	Fall River, Mass.	1874	City.	N. Watuppa Lake.	Pumping.	Worthington,	Bituminous.	Georges Cr.		10	

11	Concord, N. H.	1872	City.	Penacook Lake.	Pumping.	. . . . .	. . .	....	.....	...	...
12	Fall River, Mass.	1874	City.	N. Watuppa Lake.	Pumping.	Worthington, Davidson.	Bituminous.	Georges Cr.	....	10	...
13	Fitchburg, Mass.	1873	City.	Storage Reserv.	Gravity.	. . . . .	. . .	...	....	...	...
14	Holyoke, Mass.	1873	City.	Lakes, Streams & Manhan River.	Gravity.	. . . . .	. . .	....	....	...	...
15	Lawrence, Mass.	1874	City.	Merrimac River (filtered).	Pumping.	Barr.H Morris,L	Bituminous.	Georges Cr. &Poc'h'tas.	4 88	8	...
16	Lowell, Mass.	1870 1893	City.	555 Driven Wells.	Pumping.	Morris, Worthington, Deane, Knowles.	Bituminous.	....	5 48	...	...
17	Lynn, Mass.	1871	City.	Ponds and River.	Pumping.	Leavitt, Loretz.	Bituminous.	Georges Cr.	5 00	10	...
18	Madison, Wis.	1881	City.	Artesian Wells.	Pumping.	Allis, Knowles.	Anthracite.	Pea.	5 37	...	...
19	Maynard, Mass.	1889	Town.	White Pond.	Pumping.	Blake.	Bituminous.	Georges Cr.	4 65	20	...
						Chestnut	*Hill High*	*Service*	*Station.*		
						Holly, Quintard, Iron Works, Allis.	Bituminous.	Georges Creek, Loyal Hanna.	4 85	11	...
							Anthracite.	Screen'gs.			
20	Metropolitan Water Works, Mass.	1848 1872 1895	State of Massachusetts.	Lake Cochituate, Sudbury River, Nashua River.	Pumping.	*Chestnut*	*Hill Low*	*Service*	*Station.*		
						Holly.	Bituminous.	Georges Creek, Loyal Hanna.	4 95	10	...
						Spot	*Pond*	*Station.*			
						Blake, Holly.	Bituminous.	Loyal Hanna, Georges Creek.	5 26	11	...
							Anthracite.	Bu'kwh't			

H=High service. L=Low service.

1902.—TABLE 1.—*Continued.*—GENERAL AND PUMPING STATISTICS.

Number.	Name of City or Town.	Date of Construction of Works.	By Whom Owned.	Source of Supply.	Mode of Supply.	1	2.—Description of Fuel Used.				
						Builders of Pumping Machinery.	*a* Kind.	*b* Brand of Coal.	*c* Av. Price per Gross Ton.	*d* Per Cent. of Ash.	*e* Wood. Price per Cord.
21	Middleboro, Mass.	1885	Fire Dist.	Well near Nemasket River.	Pumping.	Deane.	Bituminous.	Poc'h'tas, Cumberland.	$4 50 5 90	...	...
22	Middletown, Conn.	1866 1897	City.	Impounding Res.	Gravity.	. . . . .	. . .	....	....	...	...
23	Minneapolis, Minn.	1868	City.	Mississippi River.	Pumping.	Hardenburg, Waters, Pray, Worthington, Holly.	Sawdust, Edgings, etc. (also water power).	....	....	...	...
24	New Bedford, Mass.	1866 1895	City.	Quittacas Ponds.	Pumping.	Dickson.	Bituminous.	Poc'h'tas.	4 95	7	$4 00
25	New London, Conn.	1872	City.	Lake Konomoc.	Gravity and Pumping.	. . . . .	. . .	....	....	...	...
26	Newton, Mass.	1876	City.	Collecting gallery near Charles Riv.	Pumping.	Blake, Worthington.	Bituminous. Anthracite Screenings.	Georges Creek, Pa.	5 09	9	6 00
27	Oberlin, Ohio.	1887	Village.	East branch Vermilion River.	Pumping.	Deane.	Bituminous.	Poc'h'tas.	4 00	...	...
28	Plymouth, Mass.	1855	Town.	Great and Little South Ponds, Lout Pond.	Gravity (L) and Pumping (H)	Worthington.	Bituminous.	Various.	6 00	...	...
29	Providence, R.I.	1870	City.	Pawtuxet River.	Pumping.	Worthington, Corliss, Holly.	Bituminous. Bituminous. Anthracite.	Georges Cr. Georges Cr. Egg (Pa.).	5 21 4 66 5 35	10 14 19	4 50 4 50 4 00

30	Reading, Mass.	800	Town.	Filter Gallery.	Pumping.	Blake.	Bituminous. Coke.	Georges Cr.	5 90	...	...
31	Reading, Pa.	1819	City.	Creeks & Springs.	Gravity, 60%. Pumping, 40%.	Worthington.	Anthr., Bit. & Riv. Coal.	....	3 11	14	3 50
32	St. John, N. B.	1851 1859	City.	East Side, Little River. West Side, Spruce Lake.	Gravity (L). Pumping (H).	.....	Water Power.	....	....	...	...
33	Somerville, Mass.	1868	City.	Metropolitan W.W.	.....	.....	...	....	....	...	...
34	Springfield, Mass.	1864 1873 1890	City.	Impounding Res's.	Gravity.	.....	...	....	....	...	...
35	Taunton, Mass.	1876	City.	Elder's and Assawompsett Ponds.	Pumping.	Holly, Allis.	Bituminous.	Cumberland.	4 20–5 00 6 00–6 50	12 10	...
36	Waltham, Mass.	1872	City.	Filter Basin near Charles River.	Pumping.	Barr, Worthington.	Bituminous.	Georges Cr. Welsh.	5 64	12	...
37	Ware, Mass.	1886	Town.	Wells.	Pumping.	Dean, Warren.	Bituminous.	....	8 43	...	5 00
38	Wellesley, Mass.	1884	Town.	Wells.	Pumping.	Blake.	Bituminous. Anthracite.	Puritan. Screen'gs.	4 95 1 50	10	3 50
39	Westerly, R. I.	1886	Town.	Driven Wells.	Pumping.	Worthington.	Bituminous.	Georges Cr.	....	...	...
40	Whitman, Mass.	1883	Town.	Well.	Pumping.	Blake, Worthington.	...	....	...	...	...
41	Winchendon, Mass.	1896	Town.	Well.	Pumping.	Blake.	Bituminous.	Pardee.	5 04	7	...
42	Woburn, Mass.	1872	City.	Filter Gallery near Horn Pond.	Pumping.	Worthington, Blake.	Bituminous	Elk Gard'n Georges Creek, etc.	5 12	9	...
43	Woonsocket, R.I.	1884	City.	Crook Fall Brook.	Pumping.	Worthington, Deane.	Bituminous	Poc'h'tas, New River, Georges Cr.	5 55	8	3 00
44	Yonkers, N. Y.	1874	City.	Sprain and Grassy Sprain Brooks, and Tube Wells.	Pumping.	Wright, Worthington, Camden.	Bituminous.	Georges Cr.	3 85 10 50	...	10 00

H=High service. L=Low service.

1902.—TABLE 1, *Concluded.*—PUMPING STATISTICS.

Number.	3 Coal Consumed for the Year. (Lbs.)	4 Lbs. of Wood ÷ 3 = Equivalent Coal.	4a Amount of Other Fuel Used.	5 Total Equivalent Coal Consumed for the Year. (Lbs.) (3) + (4).	6 Total Pumpage for the Year in Gallons.	7 Average Static Head against which Pumps Work. (Feet.)	8 Average Dynamic Head against which Pumps Work. (Feet.)	9 Number of Gallons Pumped per Lb. of Equivalent Coal.	10 Duty in Foot-pounds per 100 Pounds of Coal. No Deductions.	11 Cost per Million Gallons pumped into Reservoir, figured on Pumping Station Expenses.	12 Cost per Million Gallons raised 1 Foot high, figured on Pumping Station Expenses.
1	3 058 497 1 188 461	3 000 500	...	3 061 497 1 188 961	1 198 128 803[1] 167 400 508[2]	95 120	110 120	391 141	35 897 900 14 091 300[4]	$ 9 29 33 21	$0 085 0 278
2	528 275	..	...	. . .	158 024 210	..	188 225	310	58 200 000	....	....
3	4 728 800	3 667	...	4 732 467	1 069 661 847[3]	..	113	226	21 301 161	7 34	0 065
4	. . . .	..	...	. . .	. . . .	....	....	....	....	....	....
5	231 035	..	...	. . .	21 946 359[3]	275	317	95	25 108 771	73 29	0 23
6	482 071	0	0	482 071	497 300 329[3]	38	43	1 032	36 994 933	3 56	0 082
7	. . . .	..	...	. . .	293 386 475	289	316	..	....	29 55	0 10
8	4 097 200	500	...	4 097 700	2 930 553 545[3]	158	194	715	115 974 363	5 53	0 028
9	. . . .	..	...	. . .	. . . .	....	....	....	....	....	....
10	91 984 190	..	...	. . .	25 537 131 076[3]	173	205	278	47 489 432	5 32	0 026
11	295 884	..	...	. . .	148 876 167	..	....	500	....	....	....
12	4 882 075	..	...	. . .	1 593 248 921	..	186	326	....	11 94	....
13	. . . .	..	...	. . .	. . . .	....	....	....	....	....	....
14	. . . .	..	...	. . .	. . . .	....	....	....	....	....	....
15	391 533H 2 271 267L	..	...	391 533H 2 271 267L	127 844 980[3]H 1 122 435 290[2]L	295H 152L	323H 185L	327H 494L	88 074 104H 76 248 429L	12 12	0 076H 0 058L
16	9 012 775 3 749 273[5]	.. 2 400	...	9 015 175 3 751 673[5]	2 090 924 110 2 068 814 990[5]	.. 156	.. 162	232 551[5]	.... 74 646 252[5]	.... 18 84	.... 0 116
17	2 686 600	..	...	2 686 600	1 709 855 000	147	149	636	87 757 210	6 43	0 043
18	1 635 100	..	...	. . .	458 815 100	201	228	....	....	....	....
19	299 778	..	...	299 778	54 884 545[3]	190	212	183	31 240 547	30 29	0 143
20											
	Chestnut	*Hill*	*High*	*Service*	*Station.*						
a	380 417	..	...	. . .	273 900 000	..	120	720	75 130 000	9 30	0 078
c	443 134	..	...	. . .	503 390 000	..	124	1 136	120 700 000	4 66	0 038
e	8 078 166	..	...	. . .	10 118 610 000	..	128	1 253	136 010 000	3 89	0 030

	Chestnut	*Hill*	*Low*	*Service*	*Station.*					
f	8 275 464	..	...	. . .	27 491 950 000	..	42	3 376	121 340 000	1 36	0 032
		Spot	*Pond*	*Station.*							
h	2 267 456	..	...	. . .	2 919 010 000	..	124	1 287	134 880 000	4 51	0 036
21	586 700	..	...	. . .	87 802 000[4]	182	203	150	25 316 468	28 44	0 14
22	. . . .	..	...	. . .	. . . .	..	...	...	....	....	....
23	16 251	..	32 454[5]	19 028 160	7 094 120 905	62 to 208	abt. 225	348	65 307 167 / 71 022 860	....	....
24	2 806 875	183	...	2 807 058	2 307 304 830[2]	167	188	822	128 939 311	6 52	0 035
25	. . . .	..	...	. . .	. . . .	..	...	...	....	....	....
26	1 994 050	6 000	...	2 000 050	705 079 996[3]	234	257	352	75 561 000	14 39	0 056
27	354 000	..	...	354 000	48 837 000[3]	80	80	139	9 205 000	35 70	0 49
28	429 050	..	...	429 050	179 283 864	65	72	418	25 032 320	16 86	0 23
29	4 850 576	333	150 350[7]	. . .	3 974 820 574[3]	169	177	637[8]	[9]94 072 700	6 68[L]	0 038[L]
	567 000	8 333	...	575 333	345 591 035[2]	171	176	601	88 325 500	17 38[H]	0 122[H]
	913 287	1 484	...	914 771	519 385 796[2]	112	126	568	59 863 100		
30	478 356	..	...	. . .	53 269 837[3]	219	240	111	21 871 432	62 65	0 261
31	4 461 995	1 800	...	4 463 795	1 310 382 489[3]	212	251	294	61 451 659	9 48	0 038
33	. . . .	..	...	. . .	. . . .	..	...	...	....	....	....
34	. . . .	..	...	. . .	. . . .	..	...	...	....	....	....
35	1 099 500	..	...	. . .	560 170 211	..	67	509	28 489 883	12 37	0 184
	390 600	..	...	. . .	450 041 476[9]	..	...	...	....		
36	1 686 040	..	...	. . .	888 826 183[3]	164	180	528	83 024 400	11 89	0 066
37	636 379	1 200	...	637 579	123 429 365[3]	221	244	194	39 394 933	29 04	0 12
38	544 666	670	...	545 336	93 805 540[3]	260	280	172	39 935 706	28 53	0 102
39	1 166 290	..	...	. . .	221 053 500	195	210	191	33 450 000	21 24	0 101
40	386 336	..	...	. . .	44 615 667	..	...	...	....	....	....
41	219 687	..	...	219 687	34 918 248[2]	240	280	193	44 767 737	28 40	0 101
42	1 675 400	..	...	. . .	444 682 350[3]	200	216	265	47 813 571	18 87	0 087
43	1 500 900	495	..	1 501 395	360 211 747[2]	239	239	240	47 914 146	16 94	0 07
44	5 012 777	..	...	. . .	1 449 747 837	185	289	...	....	11 55	....

[1] By Venturi Meter.
[2] With allowance for slip.
[3] Without allowance for slip.
[4] Water pumped twice.
[5] Station No. 1 only.
[6] Cords sawdust; 1 cord equivalent to 585.82 lbs. coal.
[7] Gallons fuel oil.
[8] For time when coal was used.
[9] Included in the preceding figure.
[H] High service.
[L] Low service.
a Engine No. 1.
c Engine No. 3.
e Engine No. 4.
f Engines Nos. 5, 6, and 7.
h Engine No. 9.

1902.—TABLE 2.—FINANCIAL STATISTICS.

Number.	Name of City or Town.	Receipts.						
		Balance Brought Forward.		Water Rates.			Municipal Departments.	
		a	b	A	B	C	D	E
		From Ordinary Receipts.	From Extraordinary Receipts.	Fixture Rates.	Meter Rates.	Total from Consumers.	For Hydrants.	For Fountains.
1	Atlantic City, N. J.	$ 9 696 93	$ 38 602 85	....	....	$102 906 98	....	....
2	Attleboro, Mass.	....	1 594 81	....	....	25 263 08	....	....
3	Bay City, Mich.	13 878 67	....	$9 440 23	$15 103 83	24 544 06	....	....
4	Belmont, Mass.	3 617 09	2 783 17	....	12 293 02	12 293 02	....	....
5	Billerica, Mass.	....	45 41	1 357 61	1 427 32	2 784 93	$ 2 300 00	....
6	Brockton, Mass.	....	5 395 07	6 042 72	84 390 41	90 433 13	3 000 00	....
7	Burlington, Vt.	....	....	8 246 09	34 571 38	42 817 47	3 480 00	$ 244 50 [2]
8	Cambridge, Mass.	1 583 30	....	194 466 70	132 000 00	326 466 70	....	....
9	Chelsea, Mass.	....	....	77 000 30	23 629 86	100 630 16	2 242 80	13 50
10	Cleveland, Ohio	0	169 829 09	430 361 30	433 778 81	864 140 11	....	....
11	Concord, N. H.	....	....	29 314 64	33 514 50	62 829 14	....	....
12	Fall River, Mass.	59 064 78	....	3 559 59	171 677 36	175 236 95	....	....
13	Fitchburg, Mass.	....	....	23 210 39	42 585 31	65 795 70	....	....
14	Holyoke, Mass.	3 608 76	....	77 888 25	23 873 35	101 761 60	....	....
16	Lowell, Mass.	....	....	....	....	....	....	....
17	Lynn, Mass.	....	....	116 162 92	86 865 14	204 028 06	....	....
18	Madison, Wis.	6 493 59	....	....	....	29 250 46	....	....
19	Maynard, Mass.	3 110 33	....	4 560 42	1 807 33	6 367 75	2 000 00	6 60

21	Middleboro, Mass.	3 992 21	....	3 635 84	6 922 41	10 558 25	....	....
22	Middletown, Conn.	39 376 23	839 86	25 592 19	5 274 79	30 866 98	5 195 00	....
23	Minneapolis, Minn.	218 796 19	....	....	....	232 082 84	....	....
24	New Bedford, Mass.	12 561 30	11 368 74	73 990 25	38 116 19	112 106 44	....	....
25	New London, Conn.	....	75 645 34	....	....	51 668 02	11 840 00[1]	150 00[1]
26	Newton, Mass.	....	....	3 618 00	103 667 00	107 285 00	....	840 00
27	Oberlin, O.	1 162 26	....	1 300 00	5 456 75	6 756 75	....	....
28	Plymouth, Mass.	....	....	....	....	24 750 74	....	....
29	Providence, R. I.	....	....	....	....	605 307 35	....	....
30	Reading, Mass.	358 98	225 10	....	9 388 96	9 388 96	4 830 00	300 00
31	Reading, Pa.	98 272 89	....	131 860 53	43 257 00	175 117 53	....	....
33	Somerville, Mass.	....	....	163 231 98	50 733 53	213 965 51	....	....
34	Springfield, Mass.	13 063 29	....	148 379 25	75 523 83	223 903 08	19 440 00[1]	1 816 10[1]
35	Taunton, Mass.	....	8 400 46	....	....	61 621 73	....	2 033 58
36	Waltham, Mass.	7 432 80	4 013 53	60 624 80	9 589 73	70 214 53	....	....
37	Ware, Mass.	2 597 77	798 81	....	8 400 65	8 400 65	1 000 00	313 20
38	Wellesley, Mass.	5 200 65	....	....	14 151 22	14 151 22	←	4 000 00
39	Westerly, R. I.	....	....	725 00 1 995 09	19 176 97	21 897 06	2 482 12	....
40	Whitman, Mass.	....	1 986 37	2 243 42	4 116 80	6 360 22	2 740 00	....
41	Winchendon, Mass.	2 847 95	....	33 43	4 788 37	4 821 80	4 200 00	305 00
42	Woburn, Mass.	....	16 45	34 639 90	5 929 31	40 569 21	....	275 00
43	Woonsocket, R. I.	....	....	2 325 28	56 215 27	58 540 55	16 315 00	2 273 92
44	Yonkers, N. Y.	3 717 83	....	....	....	122 319 18	25 740 00	....

[1] Book-keeping account only; no cash received. [2] Paid at meter rates, and included in receipts—meter rates.

1902.—TABLE 2, *Continued.*—FINANCIAL STATISTICS.

Number.	Receipts.—*Continued.*								
	Municipal Departments.—*Continued.*					K	L	M	N
	F	G	H	I	J				
	For Street Watering.	For Public Buildings.	For Miscellaneous Uses.	General Appropriation.	Total from Municipal Departments.	From Tax Levy.	From Bond Issue.	From Other Sources.	Total Receipts.
1	. . . . .	. . . .	$ 7 855 90	. . . .	. . . .	$ 24 788 18	$ 88 152 57	$ 487 92 [1] 11 724 79	$284 216 12
2	. . . .	. . . .	. . . .	$5 000 00	. . . .	. . . .	30 000 00	4 009 16	. . . .
3	. . . .	. . . .	. . . .	4 838 32	. . . .	20 390 00	10 000 00	5 752 15	79 403 20
4	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	506 05	19 199 33
5	. . . .	$ 119 96	. . . .	749 15	$ 3 169 11	396 70	. . . .	48 21	6 444 36
6	$ 1 000 00	. . . .	. . . .	. . . .	4 000 00	. . . .	110 000 00	4 838 30	. . . .
7	1 425 82 [3]	514 01 [3]	330 52 [3]	. . . .	5 994 85	. . . .	. . . .	3 440 06	46 257 53
8	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	19 224 65	5 362 50	352 637 15
9	2 001 10	2 188 40	1 955 35	. . . .	8 401 15	. . . .	. . . .	. . . .	109 031 31
10	1 560 00	. . . .	3 823 15	. . . .	. . . .	. . . .	737 220 58	. . . .	. . . .
11	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	701 71	63 530 85
12	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	20 000	5 439 79	259 741 52
13	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	3 469 52	69 265 22
14	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	8 267 31	113 637 67
16	. . . .	. . . .	. . . .	. . . .	0	. . . .	. . . .	. . . .	197 253 90
17	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	424 175 87	7 254 59	635 458 52
18	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	10 000 00	1 292 19	47 036 24
19	. . . .	. . . .	. . . .	. . . .	2 006 60	. . . .	. . . .	675 37	12 160 05

21	. . . .	. . . .	. . . .	. . . .	1 500 00	. . . .	. . . .	785 91	16 836 37
22	. . . .	85 00	185 00	. . . .	5 465 00	. . . .	. . . .	3 888 11	40 216 09
23	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	253 125 00	344 705 16	795 584 19
24	. . . .	. . . .	. . . .	. . . .	12 000 00	65 880 00	7 500 00	. . . .	221 416 48
25	4 000 00 [2]	400 00 [2]	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	143 703 36
26	3 000 00	2 660 00	. . . .	. . . .	6 500 00	. . . .	30 425 41	14 640 28	158 850 69
27	. . . .	. . . .	. . . .	. . . .	. . . .	4 699 84	. . . .	756 91	13 376 36
28	. . . .	. . . .	. . . .	. . . .	0	. . . .	. . . .	1 313 54 [1] 874 88	26 939 16
29	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
30	300 00	. . . .	. . . .	. . . .	5 430 00	2 500 00	2 000 00	10 437 85	30 340 89
31	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	11 695 12	285 085 54
33	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	6 046 39	220 011 90
34	11 675 12 [3]	12 445 15 [3]	. . . .	. . . .	45 376 37 [3]	. . . .	. . . .	21 513 40 736 00 [3] 665 48	305 247 62
35	0	530 17	. . . .	. . . .	2 563 75	. . . .	. . . .	6 470 04	79 055 98
36	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	5 000 00	4 698 70	91 359 56
37	. . . .	211 84	223 54	. . . .	1 748 58	2 700 00	. . . .	332 37	16 578 18
38	⟶	118 68	. . . .	. . . .	4 118 68	. . . .	2 000 00	1 267 15	26 737 70
39	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	75 506 37	4 368 12 3 462 91	. . . .
40	. . . .	. . . .	. . . .	. . . .	. . . .	2 000 00	. . . .	694 74	13 781 33
41	143 16	. . . .	. . . .	. . . .	4 648 16	2 000 00	. . . .	38 73	14 356 64
42	250 00	792 00	. . . .	. . . .	1 317 00	637 44	2 000 00	1 212 61	45 752 71
43	1 483 95	1 800 49	626 64	13 500 00	36 000 00	15 300	. . . .	2 738 88	112 579 43
44	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	111 710 00	4 100 30	. . . .

[1] Ordinary balance (overdrawn). [2] Book-keeping account only; no cash received. [3] Paid at meter rates, and included in receipts — meter rates.

1902.—TABLE 2, *Continued.*—FINANCIAL STATISTICS.

Number.	Maintenance Expenditures.			DD	EE	FF	Construction Expenditures.				
	AA Operation.	BB Special.	CC Total Maintenance.	Interest on Bonds.	Payment of Bonds.	Sinking Fund.	GG Extension of Mains.	HH Extension of Services.	II Extension of Meters.	JJ Special.	KK Total Constr'tion.
1	. . .	. . .	$44 468 95	$54 191	....	$19 700	$24 995 79	$8 045 16	$6 059 80	$46 174 61	$85 275 36
2	. . .	. . .	10 941 81	14 120	....	5 200	. . .	. . .	. . .	. . .	32 038 13
3	$13 924 65	. . .	13 924 65	20 390	$20 000	. . .	11 044 80	. . .	583 90	. . .	11 628 70
4	1 480 23	$4 683 09 [1]	6 163 32	1 690	2 250	520	812 15	789 46	364 95	160 69	2 127 25
5	2 402 25	. . .	2 402 25	3 600	....	. . .	. . .	390 90	. . .	51 21	442 11
6	19 458 49	. . .	19 458 49	33 762 50	....	. . .	28 077 59	2 366 40	6 992 41	62 919 35	100 355 75
7	30 891 35	. . .	. . .	9 920	....	4 272 01	897 80	276 37	. . .	. . .	1 174 17
8	59 943 64	11 658 32	. . .	129 579	....	120 828 75	13 970 34	2 355 23	3 028 80	5 947 60	. . .
9	15 599 19	32 178 83 [1]	47 778 02	12 000	....	5 410	1 391 15	937 65	42 34	977 85	3 348 99
10	242 506 34	. . .	242 506 34	132 370	....	. . .	256 617 34	0	155 019 60	585 276 83	996 913 77
11	. . .	. . .	9 687 83	25 450	....	. . .	4 812	2 197 89	987 08	5 910 36	23 907 33
12	51 777 49	. . .	. . .	93 975	....	. . .	. . .	. . .	. . .	. . .	20 000 00
13	. . .	. . .	. . .	. . .	....	. . .	. . .	. . .	. . .	. . .	. . .
14	28 095 67	1 547 72	29 643 39	12 000	....	13 000	1 091 06	. . .	602 25	16 465 42	18 158 73
16	. . .	. . .	97 011 14	49 409	31 600	. . .	. . .	. . .	. . .	. . .	25 501 72
17	73 897 23	. . .	73 897 23	79 248 75	....	83 027 59	3 804 77	7 350 23	. . .	179 184 68	190 339 68
18	. . .	. . .	13 551 69	. . .	....	. . .	. . .	. . .	. . .	. . .	24 960 32
19	5 790 09	. . .	. . .	5 000	....	. . .	. . .	. . .	. . .	. . .	. . .
21	5 075 72	. . .	5 075 72	2 180	....	5 000	561 76	417 11	157 60	. . .	1 136 47

22	7 382 71	830 84	8 213 55	11 407 50	....	12 289 94	7 287 76	818 25	136 09	63	8 305 10
23	. . .	. . .	97 541 23	. . .	....	. . .	23 144 58	. . .	. . .	127 755 19	149 999 77
24	39 387 44	. . .	39 387 44	75 880	30 000	28 000	20 276 79	4 256 33	2 644 97	386 49	27 564 58
25	7 345 27	. . .	. . .	18 415	....	. . .	17 677 78	2 025 61	230 93	86 139 34	106 073 66
26	17 676 81	. . .	17 676 81	98 987 50	....	. . .	8 666	10 197	5 218	12 587 69	36 668 69
27	2 908 77	. . .	2 908 77	1 540	2 000	1 159 84	2 803 61	875 44	843 84	46	4 569 89
28	10 556 08	. . .	. . .	4 594 50	7 640	. . .	2 922 16	342 60	. . .	883 32	4 148 58
29	. . .	. . .	134 104 04	. . .	....	. . .	. . .	. . .	. . .	. . .	. . .
30	7 465 68	. . .	7 465 68	8 782 50	....	. . .	1 765 67	1 359 13	422 73	10 495 77	14 043 30
31	53 006 40	1 575 24	54 581 64	15 508	....	7 500	34 682 70	0	2 733 37	113 321 68	150 737 75
33	16 704 48	19 944 60	36 649 08	6 790	29 000	. . .	11 710 15	3 667 71	762 06	. . .	16 139 92
34	23 151 26	551 18 198 43 16 664 28	. . .	85 500	....	31 833 58	3 060 71	. . .	. . .	88 365 43	91 426 14
35	27 432 76	. . .	27 432 76	33 168	....	4 398 72	4 879 22	5 064 54	1 841 89	309 35	12 095 00
36	32 064 31	. . .	32 064 31	17 237 50	....	26 037 43	. . .	. . .	. . .	. . .	7 889 50
37	7 070 99	. . .	7 070 99	1 359	2 700	. . .	. . .	. . .	. . .	. . .	3 086 21
38	6 395 49	. . .	6 395 49	11 300	....	. . .	1 468 63	1 167 37	225 00	. . .	2 861 00
39	. . .	. . .	10 511 40	10 561 40	....	. . .	. . .	. . .	. . .	. . .	83 072 41
40	. . .	. . .	4 959 07	4 000	....	2 000	. . .	. . .	. . .	. . .	801 84
41	2 666 94	. . .	2 666 94	3 720	2 000	. . .	2 415 84	943 34	442 08	. . .	3 801 26
42	13 251 55	. . .	. . .	3 676	....	25 930 03	2 230 63	909 00	. . .	. . .	3 139 63
43	13 288 71	. . .	. . .	28 280	....	. . .	⟵	17 846 72	⟶	. . .	17 846 72
44	56 354 39	. . .	. . .	80 522 92	....	19 000	. . .	. . .	. . .	. . .	101 895 95

[1] Metropolitan Water Assessment.

1902.—TABLE 2, *Concluded.*—FINANCIAL STATISTICS.

Number.	LL	MM Balance.		N		O	P	Q	R
	Unclassified Expenses.	*aa* Ordinary.	*bb* Extraordinary.	Total.	Disposition of Balance. (2)	Net Cost of Works to Date.	Bonded Debt at Date.	Value of Sinking Fund.	Average Rate of Interest. Per cent.
1	$ 73 273 16	. . . .	$ 7 307 65	$ 284 216 12	. . .	$1 260 567 74	$1 175 500	$ 147 807 76	4 75
2	. . . .	$ 1 27	3 565 84	. . . .	. . .	421 955 43	327 000	50 554 42	. . .
3	. . . .	13 459 85	. . . .	79 403 20	Deposited	618 832 85	342 000	. . . .	5 85
4	. . . .	5 792 84	655 92	19 199 33	Forward	. . . .	38 250	3 160 26	4
5	. . . .	. . . .	. . . .	6 444 36	. . .	92 147 98	90 000	5 062 75	5
6	. . . .	41 917 74	19 168 02	. . . .	. . .	1 043 871 31	915 000	420 899 61	3 75
7	. . . .	. . . .	. . . .	46 257 53	. . .	475 635 40	248 000	44 000 00	4
8	. . . .	. . . .	. . . .	347 311 68	. . .	5 724 301 60	3 350 600	. . . .	3½ to 4
9	. . . .	40 494 30	. . . .	109 031 31	C. T.	491 552 68	300 000	71 787 00	4
10	. . . .	394 041 21	. . . .	1 765 831 32	Forward	9 999 234 22	3 287 000	0	4
11	. . . .	4 485 69	. . . .	63 530 85	. . .	890 565 12	640 000	. . . .	3 94
12	. . . .	93 989 03	. . . .	259 741 52	Forward	1 988 306 45	2 060 000	700 691 67	4 6
13	37 333 16	31 932 06	. . . .	69 265 22	C. T.	408 713 39	537 000	128 286 61	. . .
14	26 849 98	13 985 57	. . . .	113 637 67	. . .	1 295 308 26	300 000	57 235 71	. . .
16	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	1 205 500	. . . .	4
17	. . . .	. . . .	208 945 27	635 458 52	Forward	2 677 710 83	2 175 300	642 797 44	4
18	1 872 34	6 651 89	. . . .	47 036 24	. . .	380 031 32	20 000	. . . .	3 9
19	. . . .	1 369 96	. . . .	12 160 05	. . .	154 000 00	125 000	17 690 69	4
21	. . . .	3 444 18	. . . .	16 836 37	Forward	118 605 66	51 500	8 886 12	4

22	. . . .	. . . .	. . . .	40 216 09	S. F.	583 861 54	280 000	44 958 26	3 65 & 4

21	. . . .	3 444 18	. . . .	16 836 37	Forward	118 [illegible] 56	32 [illegible]	3 [illegible] 12	4
22	. . . .	. . . .	. . . .	40 216 09	S. F.	583 861 54	289 000	44 958 26	3 65 & 4
23	39 296 03	508 747 16	. . . .	795 584 19	Forward	4 707 957 49	1 830 000	. . . .	3 85
24	. . . .	13 084 46	7 500 00	221 416 48	Forward	3 186 761 14	1 698 000	216 583 90	4 39
25	. . . .	. . . .	11 869 43	143 703 36	. . .	894 464 12	501 000	. . . .	3 68
26	. . . .	5 517 69	. . . .	158 850 69	. . .	2 120 937 60	2 135 000	984 825 00	4 6
27	106 79	1 092 02	. . . .	13 376 36	Extens.	92 814 52	43 000	1 159 84	3½
28	. . . .	. . . .	. . . .	26 939 16	. . .	328 378 21	111 680	. . . .	4 12
29	. . . .	. . . .	. . . .	. . . .	. . .	6 496 966 27	6 009 000	1 259 570 60	3 75
30	. . . .	49 41	. . . .	30 340 89	. . .	286 754 96	223 000	. . . .	4
31	925 46	55 832 69	. . . .	285 085 54	Forward	2 078 537 06	400 000	13 690 00	4
33	62 397 89[1] 225 70	68 809 31	. . . .	220 011 90	C. T.	801 830 14	146 000	. . . .	4
34	45 285 37[2]	10 637 38	. . . .	305 247 62	. . .	2 232 033 92	1 450 000	560 671 00	5 83
35	. . . .	. . . .	1 961 50	79 055 98	S. F.	1 294 567 50	829 200	238 012 72	4
36	. . . .	3 465 59	4 665 23	91 339 56	. . .	620 334 77	438 000	155 499 68	3 88
37	. . . .	1 649 38	712 60	16 578 18	. . .	137 843 69	36 000	. . . .	3 63
38	882 10	4 768 82	530 29	26 737 70	Forward	331 471 13	280 000	103 311 13	4
39	. . . .	. . . .	. . . .	. . . .	. . .	359 379 96	. . . .	43 137 09	. . .
40	. . . .	816 62	2 020 42	13 781 33	Construction	132 416 71	100 000	41 540 34	4
41	. . . .	2 168 44	. . . .	14 356 64	. . .	121 476 67	91 000	. . . .	4
42	. . . .	. . . .	-244 50	45 752 71	S. F.	600 595 95	72 000	. . . .	4
43	. . . .	53 090 24	73 76	112 579 43	. . .	. . . .	732 000	104 407 43	3 8
44	. . . .	. . . .	9 814 05	. . . .	. . .	1 676 984 51	1 585 000	391 572 31	5 33
	. . . .	. . . .	. . . .	. . . .	. . .	2 252 976 98	752 000	31 823 91	4 & 6

[1] Metropolitan Water Assessment.
[2] Book-keeping account only; no cash paid.
[3] Forward=carried forward to next year's account. Construction=transferred to Construction Account. C.T.=to City Treasury. Extens.=to be used for extensions. S.F.=to Sinking Fund.

1902.—TABLE 3.—STATISTICS OF CONSUMPTION OF WATER.

Number.	Name of City or Town.	1	2	3	4	5	6	7	8	9	10	11	12
		Estimated Population.						Average Consumption. (Gallons per Day.)				Cost of Supplying Water per Million Gallons.	
		Total at Date.	On Line of Pipe.	Supplied at Date.	Total Consumption for the Year. (Gallons.)	Quantity Used through Meters. (Gallons.)	Percentage of Consumption Metered.	Total.	To Each Inhabitant.	To Each Consumer.	To Each Tap.	Figured on Total Maintenance. (Item CC.)	Figured on Total Maintenance + Int'st on Bonds
1	Atlantic City, N. J	36 000	35 500	{35 500[1] / 150 000[2]}	{1 364 519 311}	. . . .	...	{3 738 000 / 5 274 000[2]}	104	{65 / 35[3]}	825	$32 59	$72 30
2	Attleboro, Mass.	12 500	11 500	....	158 024 210	. . . .	...	432 943	34	37	....	....	....
3	Bay City, Mich.	28 000	20 500	17 000	1 069 661 847	193 573 637	18	2 930 580	105	172	1264	13 02	32 08
4	Belmont, Mass.	4 300	4 100	4 000	.....	44 038 500	All	120 653[3]	28	30	194	....	....
5	Billerica, Mass.	2 800	1 800	1 330	21 946 359	. . . .	...	60 316	..	45	....	....	273 45
6	Brockton, Mass.	44 500	41 000	37 800	497 300 329	269 275 275	54	1 362 466	31	36	240	....	107 01
7	Burlington, Vt.	19 200	18 700	18 600	293 386 475	157 649 325	54	803 798	41	43	232	....	129 15
8	Cambridge, Mass.	94 152	94 152	94 152	2 930 553 545	940 768 200	32	8 028 914	85	85	551	25 24	69 47
9	Chelsea, Mass.	34 000	34 000	34 000	. . . .	179 587 485	...	. . . .	..	..	..	50 88	63 66
10	Cleveland, Ohio.	424 000	410 000	405 000	25 537 131 076	6 953 576 000	27	69 364 472	165	173	1231	9 50	14 68
12	Fall River, Mass.	108 728	...	107 653	1 593 248 921	. . . .	...	4 365 065	40	41	...	....	....
13	Fitchburg, Mass.	32 000	....	27 500	1 058 500 000[4]	. . . .	...	2 900 000[4]	..	105	....	....	....
14	Holyoke, Mass.	47 043[5]	46 543	46 043	1 751 410 900[4]	460 111 500	26	4 798 386[4]	102	104	1300	....	....
15	Lawrence, Mass.	68 500	...	65 000	1 250 280 270	567 162 000	45	3 425 425	50	53	537	50 47	76 14
16	Lowell, Mass.	100 000	...	....	. . . .	. . . .	...	5 729 325	57	...	....	....	....
17	Lynn, Mass.	75 000	74 000	74 000	1 709 855 000	460 000 000	25	4 684 534	62	63	360	43 27	90 00
18	Madison, Wis.	20 000	...	18 792	458 815 100	139 568 692	30	1 257 027	63	67	402	....	.....
19	Maynard, Mass.	3 500	3 000	2 800	54 884 545	. . . .	20	150 368	43	...	...	....	....
20	Met. W. W., Mass.	874 200	...	....	39 152 660 000	. . . .	...	107 268 000	123	...	...	....	....
21	Middleboro, Mass.	{T'n 7 000 / D'st 4 400}	4 100	3 900	87 802 000	36 782 963	42	240 553	54	61	280	....	82 64
22	Middletown, Conn	18 000	14 000	12 500	456 250 000	70 836 000	15	1 250 000	69	100	657	18 00	43 00
23	Minneapolis, Minn	225 000	150 000	135 000	7 094 120 905	1 652 966 650	23	19 435 947	86	144	...	....	....
24	New Bedford, Mass	70 000	62 000	61 000	2 325 807 038	619 398 061	27	6 372 074	91	104	663	16 94	49 96
25	New London, Conn.	19 000	17 800	16 800	478 475 000	. . . .	...	1 310 900	69	78	390	....	....
26	Newton, Mass.	36 400	35 700	35 400	703 495 793	439 000 000	62	1 927 386	53	54	264	....	166 10
27	Oberlin, Ohio	4 800	4 000	3 000	48 837 000	18 189 000	37	134 000	28	45	183	59 60	91 16
29	Providence, R. I.	198 400	198 400	198 400	4 220 646 056	. . . .	60[6]	11 563 414	58	58	508	....	....
30	Reading, Mass.	5 000	14 860	4 385	53 269 837	. . . .	...	145 944	29	33	128	140 14	305 16
31	Reading, Pa.	84 060	83 800	83 980	3 292 453 769	1 130 258 679	34	9 020 000	107	107	512	16 58	21 29
32	St. John, N. B.	43 902	42 312	42 312	2 531 593 800	549 772 680	22	{6 072 048[8] / 864 000[7]}	139	146	...	....	....
33	Somerville, Mass.	65 500	65 500	....									

33	Somerville, Mass.	65 500	65 500	65 500	. . .	[1] 354 171 716	...	. . .	[2] 128	...	...	....	....
34	Springfield, Mass.	64 675	56 000	51 000	3 029 500 000 [4]	464 341 248	15	8 300 000 [4]	[2] 128	[3] 162	[3] 812	....	....
35	Taunton, Mass.	31 036	28 000	27 000	560 170 211	245 734 618	44	1 534 740	49	54	327	....	108 18
36	Waltham, Mass.	24 950	24 580	24 550	888 826 183	51 485 950	6	2 435 332	98	99	715	36 08	55 47
37	Ware, Mass.	8 263	7 783	7 690	123 429 365	74 250 636	60	338 163	41	44	434	....	....
38	Wellesley, Mass.	5 240	5 185	5 147	93 805 540	48 377 249	52	257 001	49	49	277	68 17	188 63
39	Westerly, R. I.	11 500	10 000	9 000	221 053 500	. . . .	...	605 300	60	67	440	....	....
40	Whitman, Mass.	6 434	...	....	44 615 667	. . . .	...	122 235	19	...	...	....	....
41	Winchendon, Mass.	5 300	3 200	2 576	34 918 248	12 888 890	37	95 667	19	38	193	76 14	182 48
42	Woburn, Mass.	14 250	14 200	14 200	444 682 350	41 255 670	9	1 218 307	85	85	411	....	29 81
43	Woonsocket, R. I.	34 974	34 474	34 474	361 139 462	278 268 469	77	989 423	28	29	405	....	115 40
44	Yonkers, N. Y.	52 000	51 000	51 000	1 657 437 214	880 882 333	53	4 540 924	87	89	826	....	....

[1] Permanent population. [2] In summer. [3] Based on meters. [4] Estimated. [5] School census. [6] Domestic. [7] Pulp mill, etc.

1902.—TABLE 4.—STATISTICS RELATING TO DISTRIBUTION SYSTEM.—MAIN PIPES.

Number.	Name of City or Town.	1 Kind of Pipe.	2 Sizes of Pipes. (Inches.)	3 Length Extended During the Year. (Feet.)	4 Length Discontinued During the Year. (Feet.)	5 Total Length in Use. (Miles.)	6 Cost of Repairs per Mile.	7 Number of Leaks per Mile.	8 Length of Pipe Less than 4 Ins. Diam. (Miles.)	9 Hydrants. Number Added.	10 Hydrants. Total in Use.	11 Gates. Number Added.	12 Gates. Total in Use.	13 Gates. Number Smaller than 4-Inch.	14 Gates. Number of Blow-off Gates.	15 Range of Pressure on Mains. (Pounds.)
1	Atlantic City, N. J.	C. I.	4 –20	21 625	450	54 8	..	..	2 6	41[1]	592[1]	73	. .	.	4	40–55
2	Attleboro, Mass.	W. I., C. I., Cem. L.	1 –16	30 729	..	39 0	..	0 5	. .	29	307	.	. .	.	.	54–62
3	Bay City, Mich.	C. I., Wyckoff.	4 –20	14 848	5 609	47 3	$20 15	1 4	. .	13[1]	430[1]	27	736	1	13	35–100
4	Belmont, Mass.	C. I.	4 –12	613	0	18 0	..	0	0 5	1	141	1	215	19	11	15–100
5	Billerica, Mass.	C. I.	6 –12	..	..	9 7	2 12	1	. .	..	101	.	84	.	4	54–120
6	Brockton, Mass.	W. I., Cem. L., C. I.	6 –30	29 579	0	74 4	2 62	0 4	0 7	46	696	69	917	10	29	47–56
7	Burlington, Vt.	Cem. L., W. I., C. I.	4 –30	4 835	2 244	39 0	8 18	0 7	2 7	1	214	19	652	60	14	70–85
8	Cambridge, Mass.	C. I.	2 –40	4 392	..	125 1	1 23	0 02	3 3	23	1 001[1]	39	. .	.	.	45–55
9	Chelsea, Mass.	C. I.	4 –16	1 650	..	38 8	..	3	0 1	5	290	7	416	0	31	50–75
10	Cleveland, Ohio	C. I., Steel.	3 –48	86 567	17 836	577 0	..	..	2 5	186	6 648	341	12465	6	.	20–80
11	Concord, N. H.	C. I., Cem. Lined.	. .	15 622	12 466	61 8	..	..	. .	5	277	17	800	.	.	....
12	Fall River, Mass.	C. I.	6 –24	12 956	..	92 8	..	..	. .	40	1 031	34	1 020	.	.	80
13	Fitchburg, Mass.	C. I.	2 –30	2 502	..	68 0	..	..	. .	4	516	9	573	.	.	75 L. S. 155 H. S.
14	Holyoke, Mass.	W. I., C. I., Cem. L.	½–30	2 300	0	83 3	7 44	0 05	5 7	7	771	13	792	15	31	45–100
15	Lawrence, Mass.	C. I., Ld. Lined.	1 –30	11 264	3 953	81 9	..	..	7 7	16[1]	773	44	1 039	0	12	65–125
16	Lowell, Mass.	. . . . .	. .	13 369	..	131 9	..	..	. .	..	1 120	54	1 289	.	.	....
17	Lynn, Mass.	Cem. Lined, C. I.	4 –36	3 940	..	132 5	136 00	1 61	. .	1	963	15	992	.	65	40–60
18	Madison, Wis.	C. I.	4 – 8	12 374	..	38 3	..	..	. .	19	194	14	260	2	2	53–65
19	Maynard, Mass.	C. I.	4 –12	2 595	..	9 5	0 99	0 5	0	2	90	5	85	0	2	90–95
20	Met. Water Works	C. I., C. L.	6 –60	53 300	..	82 1	..	..	. .	..	. .	48	328	.	.	....
	Met. Water Dist. total in cities and towns.	C. I., C. L., Kal.	4 –60	320 000	..	1 457 1	..	..	. .	654	12 033	.	. .	.	.	....
21	Middleboro, Mass.	C. I.	4 –12	1 766	1 230	17 3	..	0 06	0	0	121	3	178	0	6	40–60
22	Middletown, Conn.	C. I.	3 –20	4 978	..	31 3	70 11	..	1 3	6	209	12	268	18	45	40–125
23	Minneapolis, Minn.	C. I., W. I., Steel.	6 –50	11 618	0	278 8	..	0 41	. .	28	3 340	23	2 366	.	45	....
24	New Bedford, Mass.	C. I.	4 –36	18 433	2 507	97 9	8 08	0 14	1 1	43	979	45	1 137	78	97	25–95
25	New London, Conn.	Cem. Lined, C. I.	4 –24	24 520	48	57 8	5 67	0 33	3 3	19	328	25	366	.	34	40–48
26	Newton, Mass.	C. I.	4 –20	4 380	0	138 7	2 00	0 05	3	2	963	6	815	48	392	80–86
27	Oberlin, Ohio.	C. I.	4 –12	3 856	..	10 4	0	0	0 3	7	96	6	66	2	2	27–32

28	Plymouth, Mass.	Cem. Lined, W. I.	2	–20	6	031	1	818	45	6	17	16	1	77	10	9	6	186	10	461	138	36	....
29	Providence, R. I. H. P. Fire Service.	C. I.	6	–36	28	240	1	199	336	2	0	77	0	08	0		41[1]	1 960[1]	54	3 530	0	32	64–73
		C. I.	12	–24	..	..	..		5	6	..		..		..		0	92	.	31	.	4	114
30	Reading, Mass.	C. I.	6	–12	2	270	0		28	5	0	48	0		0		2	163	5	248	0	14	63–78
31	Reading, Pa.	C. I.	1¼	–36	24	611	19	227	102	7	17	42	0	55	0	8	58[1]	818[1]	162	2 457	9	.	10–133
32	St. John, N. B.	C. I., W. I., Cem. L.	1¼	–20		842		0	49	4	9	66	0	78	1	9	0	392	6	1 195	126	133	11–77
33	Somerville, Mass.	C. I.	4	–20	6	622	..		87	8	2	85	0	16	..		31	999	35	1 283	..	123	60–100
34	Springfield, Mass.	C. I., W. I., Cem. L.	1	–36	8	449	2	536	147	3	5	95	0	24	7	9	8[1]	972[1]	59	1 983	403	89	30–120
35	Taunton, Mass.	C. I.	4	–30	3	580	0		79	89	29	58	0	21	1	7	9	803	7	570	12	59	45
36	Waltham, Mass.	C. I., Cem. Lined.	2	–24	10	305	8	546	52	0	2	56	0	2	2	2	6	350	16	711	39	60	50–70
37	Ware. Mass.	C. I.	4	–12		336	0		12	2	..		..		0	8	1	117	2	123	11	3	90–95
38	Wellesley, Mass.	C. I., Cem. Lined.	4	–12	1	450	3	100	30	8	0	54	0	6	0	2	3	285	3	228	3	4	70–75
39	Westerly, R. I.	C. I.	4	–12	46	902	0		31	6	..		0	16	..		25	149	50	184	.	7	82–92
40	Whitman, Mass.	C. I., Cem. Lined.	..	..	..	..	..		17	5	..		0		..		..	157	2	92	.	.	65
41	Winchendon, Mass.	C. I., W. I.	2	–14	4	933	..		17	5	..		..		2	0	3	134	5	180	30	18	40–151
42	Woburn, Mass.	Cem. Lined, C. I.	4	–14	2	319	..		54	4	15	29	0	53	5	0	4	358	4	427	51	16	70–75
43	Woonsocket, R. I.	C. I.	4	–20	7	108	..		48	0	1	22	0	12	0		12	571	17	475	0	15	50–120
44	Yonkers, N. Y.	C. I.	3	–30	22	070	3	484	88	8	14	03	0	9	0	8	51	909	33	583	3	24	45–130

[1] Public hydrants only.

1902.—TABLE 5.—STATISTICS RELATING TO DISTRIBUTION SYSTEM.—Service Pipes.

Number.	Name of City or Town.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		Service Pipe.					Service Taps.				Meters.				Motors & Elevators.	
		Kind.	Sizes. (Inches.)	Extended. (Feet.)	Discontinu'd. (Feet.)	Total in Use. (Miles.)	Number Added.	Total in Use.	Average Length of Service. (Ft.)	Average Cost of Service for the Year.	Number Added.	Now in Use.	Percentage of Services Metered.	Percentage of Receipts from Metered Water. (B) ÷ (C).	Added.	Total in Use.
1	Atlantic City, N. J.	Tin Lined Galv. Iron.	¾–4	3 935	..	....	255	4 477	134	$15 93	258	3 662	82	..	..	0
2	Attleboro, Mass.	....	....	....	..	....	..	....	..	....	167	1 449	..	..	..	3
3	Bay City, Mich.	Lead, W. I., C. I.	¾–8	....	..	....	62	2 318	..	....	57	938	40	62	..	..
4	Belmont, Mass.	W. I., Cem. Lined.	1	1 186	0	6	22	621	51	35 88	22	621	100	100	..	..
5	Billerica, Mass.	W. I., Cem. Lined.	1 –1½	1 707	..	2 9	18	228	69	....	20	83	36	51	..	..
6	Brockton, Mass.	W. I., Ld. Lined, Cem. Lined, C. I.	¾–8	12 603	162	36 3	204	5 671	60	11 60	581	5 104	90	93	0	8
7	Burlington, Vt.	G. I., C. I., Lead.	¾–6	1 536	73	18 8	44	3 464	29	7 80	126	2 527	73	81	0	35
8	Cambridge, Mass.	Galv. Iron.	¾–2	6 836	..	113 2	161	14 569	41	17 40	254	2 113	15	44	..	..
9	Chelsea, Mass.	Lead.	¾–2	1 694	..	31 9	59	6 257	28	15 89	6	113	2	22	0	6
10	Cleveland, Ohio	Lead, Galv. Iron.	¾–6	....	..	....	1686	56 816	..	....	7755	11 099	20	50	1	197
11	Concord, N. H.	....	....	1 443	..	14 8	53	3 331	..	....	61	1 203	37	53	..	..
12	Fall River, Mass.	Lead.	¾–2	....	..	....	207	7 282	..	....	218	6 973	96	98	..	..
13	Fitchburg, Mass.	W. I., Cem. L'nd., C. I.	¾–8	4 174	..	50 4	87	4 623	..	....	72	2 594	56	65	4	101
14	Holyoke, Mass.	Cem. L'nd., Rubber L'nd., Enam., Ld. L., G. I., C. I.	¾–4	540	11	14	27	3 691	20	16 62	5	243	7	23	1	98
15	Lawrence, Mass.	G. I., Ld., Ld. L'nd, C. I.	¾–8	8 951	1404	49 3	165	6 375	40 8	22 60	379	5 324	83	86	2	17
16	Lowell, Mass.	....	....	7 720	..	82 0	195	10 984	..	....	..	7 129	65	..	..	..
17	Lynn, Mass.	Cem. Lined, Lead Lined.	¾–4	10 986	316	99 8	222	12 873	40	18 00	327	3 273	25	43	..	7
18	Madison, Wis.	Lead.	¾–2	3 834	..	15 8	166	3 132	..	....	176	2 983	95	..	..	..
19	Maynard, Mass.	Cem. Lined.	¾	1 212	0	....	38	536	49	5 56	6	85	20	..	..	2
20	Metropolitan Water District. Total in cities and towns.	....	....	....	..	....	3064	141 604	..	....	2043	13 073	9	..	..	..
21	Middleboro, Mass.	Cem. Lined, W. I., Lead.	¾–3	1 141	..	9 5	18	857	58	....	9	375	44	65	0	7
22	Middletown, Conn.	W. I., Cem. Lined.	¾–2	320	..	....	18	1 901	18	16 28	4	77	4	17	..	1
23	Minneapolis, Minn.	Lead, Galv. Iron.	¾–1	....	..	....	..	22 119	..	....	1535	7 788	35	..	0	20
24	New Bedford, Mass.	Lead, C. I.	¾–10	10 266	3603	62 7	165	9 612	34	19 98	205	1 771	18	34	3	128
25	New London, Conn.	Cem. Lined, G. I., Lead.	¾–4	2 652	215	10 3	149	3 361	18	11 20	14	265	8	..	1	18
26	Newton, Mass.	G. I., Tarred I. Lead.	¾–6	8 500	4800	81 1	122	7 311	61	36 40	181	6 279	86	97	0	17
27	Oberlin, Ohio.	Galv. Iron, Lead.	¾–4	....	..	....	72	732	25	8 00	32	464	75	80	0	0
28	Plymouth, Mass.	Lead, Cem. Lined.	¾–4	542	..	6 2	68	2 043	16	5 04	..	....	..	..	0	1

29	Providence, R. I.	Lead, C. I.	¼–10	....	..	....	591	22	758	..	....	717	19	216	84	..	4	169
30	Reading, Mass.	C. I., Cem. L'd., Ld. L'nd.	¼–6	2	566	222	15	0	32	1	136	70	42	47	31	1	018	89	100	0	3
31	Reading, Pa.	Ld., W. I , C. I . Ld. L'nd.	¼–8	....	..	....	661	17	603	..	....	138		952	5	25	1	9
32	St. John, N. B.	Ld., W. I., C. I., Cem. L'd.	¼–4	1	800	..	31	4	52	5	735	29	23	00	11		195	3	21	0	12
33	Somerville, Mass.	Ld., Ld. L'nd, Cem. L'nd.	¼–6	7	569	..	68	2	190	10	710	..	18	82	45		269	3	24	1	9
34	Springfield, Mass.	Ld., Cem. L'nd, Tarred I., G. I., C. I.	¼–6	....	..	....	187	10	221	..	....	200	3	537	35	34	8	262
35	Taunton, Mass.	Cem L'nd, Tin Lined.	¼–3	4	800	7457	45	4	101	4	698	..	52	21	116	2	050	44	..	0	17
36	Waltham, Mass.	C. I., W. I.	1 –12	5	498	2125	40	4	54	3	406	59	30	26	110		200	6	14	0	6
37	Ware, Mass.	Cem. Lined. W. I.	1 –2	1	540	845	9	8	23		780	62	....		24		778	100	100	0	9
38	Wellesley, Mass.	C. I., Cem. L , Lead L'nd.	¼–6	3	067	5994	15	4	–5		893	122	13	02	23		877	100	100	0	0
39	Westerly, R. I.	Lead., W. I.	¼–4	....	..	....	228	1	375	..	10	43	208	1	088	79	88	3	11
40	Whitman, Mass.	. . . . .	. . . .	....	..	....	22	1	030	..	....	..		490	48	65	..	..
41	Winchendon, Mass.	W. I.	1 –2	1	885	.	4	4	52		497	48	18	86	40		474	95	99	0	0
42	Woburn, Mass.	Lead L'nd, Cen . Lined.	1	....	..	....	31	2	962	..	14	45	3		72	2	12	..	9
43	Woonsocket, R. I.	Lead, C. I.	¼–6	1	944	0	7	0	130	2	441	14	14	28	115	2	118	87	96	1	13
44	Yonkers, N. Y.	Lead, C I.	¼–8	....	..	....	257	5	495	..	....	248	5	404	98	..	3	10

THE FOLLY OF RECKONING BY GALLONS, WHICH DIFFER WIDELY IN CANADA AND THE UNITED STATES, WHILE ALL COUNTRIES HAVE IDENTICAL LITERS AND CUBIC METERS.

BY FREDERICK BROOKS, C. E., BOSTON, MASS.

[*Presented September* 10, 1903.]

This subject is commonplace and hackneyed. It suggests that what has been before this convention should be reviewed from the metrological standpoint. The facts are familiar; and for that reason their importance may fail to be appreciated unless especial effort be made to draw attention to them. Many, perhaps most, of the wrong things that we do are caused by thoughtlessness rather than depravity; and it is desirable that we take advantage of being away from home to see facts in a new light. We are not merely out of New England, but out of the United States; let us look at ourselves from the outside and see ourselves as others see us. For the first time as an Association we are in Canada. Canada is an intermediary between Old England and the United States, being closely connected politically with one and geographically with the other; and she is well situated for leadership, as she has left both those countries behind.

DECIMALIZATION.

In this city of Montreal last month the great Congress of Chambers of Commerce from all parts of the British Empire passed a resolution recommending to the British government decimal coinage for the empire. In decimalization Canada and the United States have left England behind, having adopted dollars and cents and abandoned the pound, shilling and penny reckoning which they formerly used and which England continues to use. Money deserves prominent mention because of the very close analogy that exists, extending into many details, between the change in monetary reckoning and the change in weights and measures.

Our decimalization has included other things along with money; for instance, our discussion yesterday brought out the fact that Canada has adopted a ton of 2 000 pounds, which in England is called the "colonial" ton, so that the hundredweight in America is 100 pounds, not as in England 112. We have reckoned lumber by the thousand feet of board measure, instead of cubic feet, cubic yards or cords, etc.; and slating or shingling by the "square" of 100 square feet, disregarding square yards; and so on. In reality our decimalization has been less an establishing of special units than a mental habit of reckoning conformably to our "Arabic" notation; and that habit has had markedly wider exercise in America than in England. I doubt if any kind of measure can be named in which multiplying or subdividing by ten has not been introduced as a practice among us. Try such as pertain to water works. At this convention we have had some mention of annual rainfall. Those people who are sure that 12 inches used to make a foot and that the inch was divided by successive bisections hear no more of a rainfall of 4 feet 3⅞ inches than they do of a barometric reading of 2 feet 5 11/16 inches. We might have a rainfall of 51.62 inches in a year. We have stuck to the inch and used our decimal notation for expressing multiples of the inch up to very high figures; and we have insisted upon writing fractions decimally. With cast-iron water pipes it has been similar. We have heard praise given, as was deserved, to this Association's committee which recently reported on Standard Specifications and submitted extended tables of dimensions of pipes. Diameters go up to 65.20 inches and thicknesses go down to 0.34 of an inch; but there is no eighth inch or sixteenth inch as formerly written, and no foot expression of transverse dimension. Consumption of water has afforded another instance of the same kind. We have adhered to the little unit of a gallon even for immense quantities. The million of gallons, a number too large for the human mind to picture adequately to itself, we have practically made our unit of higher denomination, ignoring the various multiples of the gallon that belonged to our old tables of measures. For instance, it has been exceptional with us to express consumption by the barrel, as in the statement made this morning in Mr. Venner's paper, that, on the average, two-thirds of a barrel of water per day was disposed of for every pupil in the school-houses of Syracuse, N. Y.

In irrigation, quantities have sometimes been expressed by the acre-foot. In both these cases the attempt was probably to use familiar units of which mental conception could be formed. As for small quantities, we have in Table No. 2 of Mr. Kimball's valuable paper on "Test of Water Meters" put before us this morning, two decimals of gallons, the tenth of the gallon and the hundredth of the gallon; he does not use the binary subdivisions — the pint and gill well known to people generally.

RELATIONSHIP.

It is all very well to note that we left Old England behind. It is less flattering to our vanity, but more useful, to take up the point in which we were left behind by Canada and England. This was in the establishment of systematic relations between units, especially the relation of capacity measure to weight of water. Water was taken for the basis, not out of compliment to water-works men, but as generally recognized to be the proper reference in both ancient and modern weights and measures. It is the standard for comparison in the expression of specific gravity. The British Imperial gallon was made to hold 10 pounds of water; going upwards and downwards,—

The peck	holds	20 pounds.	The quart	holds	2½ pounds.
The bushel	„	80 „	The pint	„	1¼ „
The quarter	„	640 „	The fluid ounce	„	1 ounce (Av.)
etc.			etc.		

Simple relationship has thus been established between such of these units as are specially used for dry measures and such as are specially used for liquids. In the British Pharmacopœia, the reference manual of the apothecary, the avoirdupois ounce was introduced. The United States was left with what Great Britain long ago abandoned, separate liquid and dry measures without any simple precise relations; the name of quart we have applied sometimes to a dry measure and sometimes to a different measure for liquids. We thought less of this long-standing difference while pursuing our routine work at home than we do on coming here and listening to Mr. Janin's interesting account of the Montreal Water Works and running up against consumption expressed in gallons about 20 per cent. larger than our United States measure. It is here, where we have Canadian members with minds accustomed to

Imperial gallons, that Mr. Kimball's paper is presented with its tables full of our smaller United States gallons. The question naturally arises, What was the use of translating the results into gallons at all? The water meters Mr. Kimball tested read in cubic feet, the same in Great Britain, Canada, and the United States. He uses cubic feet in two different parts of his discussion besides the paragraph referring to the dials of the water meters. That gallons can be dispensed with in accounts is illustrated by President Walker's speaking here of a price per 100 cubic feet for water consumed. The latest edition (October, 1902) of Trautwine's "Civil Engineer's Pocket-Book" has four pages occupied with long figures for the interconversion of discharges in cubic feet per second and millions of gallons per day, both United States and Imperial, an instructive exhibit of the needless labor that has been imposed upon us by the diversity of our reckonings. An amusing instance of conflicting gallons appears in the August, 1903, Proceedings of the American Society of Civil Engineers; a paper on South African irrigation mentions the price of "Homelight" kerosene oil as 11 shillings per case of 8¼ Imperial gallons; Yankee readers may guess that it was 10 United States gallons when the case started from home.

In reality, our mental habit, even in the United States, has been to insist upon having relationship, if not simple and precise, then cumbrous and approximate. Let us briefly notice some relations that had to do with water. In their origin the old measures had relationship which has long lost any precision it ever had. Eight gallons went to the bushel and a gallon was 8 pounds; according to that a quart was 2 pounds, and there was reason in the first half of the old rhyme, "A pint's a pound the world around." The United States fluid ounce, or 16th part of a United States pint, has held a weight of water about 5 per cent. less than the ounce weight used in the United States Pharmacopœia, and over 4 per cent. more than the avoirdupois ounce. The "tun" also bears witness to ancient relationship. As nearly as I have found out, the word "tun" meant something rounded, like a tunnel, a cask. Since for centuries commerce has included large shipments of several liquids besides molasses in large casks, the capacity of vessels has been expressed as tunnage or tonnage; and with their burden in tons we have set up a corresponding large unit of weight. We still

read in our arithmetical tables that four hogsheads make 1 tun and that the barrel is half a hogshead and is 31½ gallons; the hogshead, or fourth part of the tun, contains 252 quarts according to this liquid measure. Another measure, called the "quarter," containing 256 quarts or 8 bushels, and appearing to have been similarly connected with the tun or ton, has continued in use from ancient times in England, having been a very well-known unit in the grain trade; its name and approximate magnitude are preserved in the Imperial measure as just above stated.

We have carried in mind a number of other relations which, though untrue, were well invented; as that 7½ United States gallons, or 30 quarts, were equivalent to a cubic foot; a cubic foot of water, to a thousand ounces; 1½ cubic feet per second, to a million United States gallons per day; and the water contained in an inch pipe a yard long, to a pound.

SYSTEM ADOPTED.

Our two mental habits have free play in the metric system. Instead of our ancient division of a tun into 8 barrels, we now decimalize, and regard the nearly equivalent metric ton of water as consisting of 10 hektoliters, that is to say, ten hundred liters, and the quarter part of it as 250 liters and not 256 quarts (quarter) nor 252 quarts (hogshead). Forgotten relationship is restored. The liter, being between United States quart and British quart, between liquid quart and dry quart, between wine quart and beer quart, we naturally think of it as a quart. Everybody knows the size in the form of a bottle, and knows how much its weight is reduced by the extraction of its liquid contents. That furnishes the commercial unit of weight, the kilo, or thousandth part of the ton. The name "liter" corresponds with litron, a measure of nearly the same capacity in the series of dry measures formerly in use in Belgium, in France, in Louisiana until its cession to the United States 100 years ago, and here in Canada, where its use was for a long time established by British authority; for aught I know it may still be remembered here. The kilo of water or the liter, if in cubical shape, is the cube of 1 decimeter, the measure of a length which is perfectly familiar to us all, being practically the same as the "hand," the unit of measurement of height of horses. The width of common bricks is nearer to 1 decimeter than to 4 inches. The ordinary dimension of scantlings is nearer to 1

decimeter than to 4 inches. One decimeter might have been as correctly used as 4 inches to designate the diameter of the pipes that make up a greater length than any other size in the schedule of cast-iron mains in this city submitted to this convention yesterday by Superintendent Janin; for the difference between the two may be neglected in view of the variations made in the actual interior diameters of pipes of the same nominal size. That metric measure can easily be applied to existing water-pipe sizes was mentioned in a discussion by George E. Manning when the report of the Committee on Standard Specifications was under consideration, as published a year ago in the JOURNAL of the N. E. W.W. A., vol. 16, p. 133. The metric ton of water, or ten hundred liters, if in cubical shape, is the cube of 10 decimeters or 1 meter, the fundamental unit of length; and so on. The relationship extends throughout the system instead of being, as with old measures, exceptional, fictitious or obsolete. We have the same basis for measurement of excavation, of structural work, and of everything else, as for quantity of water. If we dig out a number of cubic meters of earth for a well, that number of cubic meters of water will fill it to the brim. If we build a tank to metric dimensions and compute its capacity as a number of cubic meters, it will hold that number of tons of water. If our filter beds take care of 1 000 cubic meters per hektar, that's 100 liters per square meter, or a subsidence of 1 decimeter measured vertically. Decimal multiplying and subdividing likewise extends throughout the system, instead of being, as with old measures, forced in where it conflicts with what is customary. If for every child in the Syracuse schools there is an average of 83 liters of water per day disposed of, it is needless to add the separate statement that it is 83 per cent. of a hektoliter. If the irrigation engineer has in his mind's eye a meter's depth of water over the area of a hektar, that is 10 000 cubic meters, or 10 000 000 liters. Trautwine has three pages mostly occupied with figures for the interconversion of expressions of pressure in pounds per square inch, pounds per square foot, and head of water in inches and in feet; the exclusive use of the metric system would make these pages unnecessary, for the moving of the decimal point does not require a table of long figures to exhibit it; a pressure of 1 kilo per square centimeter or 10 metric tons per square meter corresponds to a head of 1 000 centimeters, or 10 meters, of water.

Trautwine has a table of about a page for the conversion of inches and 32ds into feet and decimals, which could be dispensed with if all multiples and subdivisions went by tens; he has no table for the conversion of cents and mills into decimals of a dollar.

Our inflexible adherence to the two mental habits above spoken of would have sufficed to account for our having adopted the metric system, even if we had not been forced into it by other considerations, especially the development of electricity and the growth of international trade. Here in Montreal three weeks ago the Congress of Chambers of Commerce of the British Empire passed a resolution favoring the completion of the introduction of the metric system throughout the empire. The publishers of the *Canadian Engineer*, having an office in this city, have published a metric chart, a copy of which is displayed in the exhibition room for water-works appliances in connection with this convention. The latest revision of the British Pharmacopœia has introduced metric weight and measure throughout. The United States Pharmacopœia has gone further and completed the transition by omitting the old medley; incongruous ounces, scruples, minims, and all are abandoned. We can hardly take up a newspaper or periodical that has not some use of metric weights and measures in it. The system hits us on every side, including the water-works side. The new edition (1903) of Professor Merriman's "Treatise on Hydraulics" introduces metric data and tables along with the old units. The plan of the Lawrence filter that Mr. Collins showed us this afternoon had figures upon it in millimeters for the sizes of sand. The paper and discussion on the Physical Properties of Water and Turbidity in the N. E. W. W. A. JOURNAL of March last were mostly in metric measure. The recent official publication of the report of the water purification investigation at New Orleans, of which Mr. R. S. Weston gave us an interesting account at one of our meetings last winter, shows extensive use of the metric system as well as of ancient weights and measures. It is a significant fact that the latest edition (October, 1902) of Trautwine's "Civil Engineer's Pocket-book" has fifty pages devoted to the subject of weights and measures; its extended treatment is appropriate to the present requirement for accurate translation of old reckonings into the metric system. For approximate translations, such as we have

to make in our heads, a revised table is submitted herewith. (See page 267.) It is the easier to remember, because the same ratios are used repeatedly; familiar relations, exact or inexact, among the old measures are adhered to, and equivalents are carefully grouped. As the hand is practically a decimeter, the yard, being 9 times as long, is 9 decimeters. The American, or net, ton is less than the English, or gross, ton by over 10 per cent.; as the English is about the same as the metric, the net ton corresponds to 9 hektoliters of water or 900 kilos. We remember the net ton as 2 000 pounds, the peck of water as 20 pounds and the United States liquid quart as 2 pounds; that is, the peck is a hundredth of the net ton and is 9 liters, while the United States liquid quart is a tenth of the peck and is 0.9 of a liter or of a cubic decimeter. The cubic foot is 30 quarts, hence 30 times 0.9, or 27, cubic decimeters; and, if of water, weighs 27 kilograms. The ounce, or thousandth part of the cubic foot of water, is then 27 grams. The smaller figures inserted in parentheses are accurate enough for use in business transactions.

WHAT ARE YOU GOING TO DO ABOUT IT?

There are a number of things to be done. Let each of us post up in his office a metric chart, the *Canadian Engineer* publishers' or any other. Let it be the rule that any plan of importance enough for a linear scale shall have a metric linear scale, and let this rule be enforced upon any plans published in the JOURNAL of the N. E. W. W. Association. Let us make known to the Secretary of the Treasury of the United States that we wish the metric system to be exclusively used in the customs service from the earliest possible moment. The thing which I have particularly to speak about is that the form recommended in this Association for water-works statistics should provide for the expression of consumption of water in metric measure, whatever other equivalent expression may be allowed along with it for a little time to come. The Association's purpose in having a Committee on Uniform Statistics is obviously to get the water works of the different cities and towns of New England to use the same form in making up statistics, so that they may be readily comparable. The same idea requires, for the sake of comparing with places outside of New England, that the form should agree with what is used else-

where. This Association has members in Canada and England, and they have statistics in gallons about 20 per cent. larger than the United States gallon. What these three countries have done to promote uniformity is to establish the international metric system, the same in the English-speaking countries and also in the non-English-speaking countries. We hear of the number of bacteria per cubic centimeter in the water supplies of continental Europe as well as of Great Britain and America. Mr. Metcalf has come back from Porto Rico and told us this evening of the metric system having been used on the military road there. There are other parts of the world where Spanish, Dutch, Japanese, and other languages are spoken, and where there are water works from whose statistics we might sometime learn by comparison.* It has been announced upon our program that a report from our Committee on Uniform Statistics is in order following this discussion of mine. I have accordingly taken the liberty of addressing notes to the members of that committee, inviting them either to report a recommendation that metric capacity measure be introduced for the expression of quantities of water consumed in the Association's form of statistics, or else to participate in the discussion of this topic and explain why not.

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*As this discussion is being revised for the printer, the September number of *Proceedings* of the American Society of Civil Engineers is issued, containing a paper of fifteen or twenty pages on Filtration for Public Water Supplies, with Especial Reference to the Double Filtration Plant at Bremen, Germany. The paper is written in metric measure throughout, and contains scarcely any mention of the ancient method of reckoning.

APPROXIMATE EQUIVALENTS.

LENGTH.

1 inch	and	2½	centimeters	(2.54)
1 foot	,,	0.3	of meter	(.3048)
1 Yard	,,	0.9	,, Meter	(.9144)
1 rod	,,	5.	meters	(5.029)
1 chain	,,	20.	,,	(20.117)
1 furlong	,,	200.	,,	(201.17)
1 mile	,,	1 600.	,,	(1 609.3)

AREA.

1 sq. inch	and	6½	sq. centim's	(6.452)
1 sq. foot	,,	0.09	of sq. meter	(.0929)
1 sq. yard	,,	0.81	,, ,,	(.8361)
1 sq. rod	,,	25.	sq. meters	(25.29)
1 rood	,,	1000.	,, ,,	(1 011.7)
1 acre	,,	0.4	of hektar	(.4047)
1 sq. mile	,,	256.	hektars	(259.)

BULK.

1 cu. inch	and	15½	cu. centimeters	(16.387)
1 cu. foot	,,	0.027	of cu. meter	(.028317)
1 cu. yard	,,	0.729	,, ,, ,,	(.7646)
100 cu. feet	,,	2.7	cu. meters	(2.8317)
(The unit of ship's measurement for register.)				
1 M board meas.	and	2 ¼	cu. meters	(2.36)
1 cord	,,	3.6	,, ,,	(3.624)

WEIGHT.

1 grain	and	.06½	of gram	(.0648)
1 troy ounce	,,	30.	grams	(31.103)
1 avoir.	,,	,, 27.	grams	(28.35)

1 pound	and	0.45	of kilo	(.4536)
60 lbs. (wheat bu.)	,,	27.	kilos	(27.216)
80 lbs. (coal bu.)	,,	36.	,,	(36.287)
1 cental	,,	45.	,,	(45.36)
112 lbs. (cwt.)	,,	50.	,,	(50.8)
1 Net Ton	,,	0.9	Met. Ton	(.9072)
1 gross ton	,,	1.	,,	(1.016)

1 U.S. liq. pint	,,	0.45	of liter	(.473)
1 ,, ,, Quart	,,	0.9	,, Liter	(.946)
1 ,, ,, gallon	,,	3.6	liters	(3.785)
1 peck	,,	9.	,,	(U.S. 8.81; Br 9.09)
1 bushel	,,	36.	,,	(U.S. 35.24; Br. 36.37)
1 ton of ship's displacement	,,	1	cu. meter.	

COMBINATIONS.

	1 horse power	and	¾	of kilowatt	(.746) POWER.
	1 foot-ton (net)	,,	0.27	,, (metric) ton-meter	(.2765)
	1 foot-pound	,,	0.13½	,, kilogrameter	(.1383) WEIGHT AND LENGTH.
	1 pound per running yard	,,	½	kilo per running meter	(.4961)
	1 ,, ,, ,, foot	,,	1 ½	kilos ,, ,,	(1.4882) WEIGHT PER LENGTH.
	1 pound per sq. foot	,,	5.	kilos per square meter	(4.882)
(About 1 Atmosphere)	1 net ton ,, ,,	,,	1.	kilo per sq. centimeter	(0.9765)
	15 lbs. ,, ,, inch	,,	1.	,, ,, ,,	(1.0546) WEIGHT PER AREA.
	1 pound ,, ,,	,,	0.07	,, ,, ,,	(.0703)
	1 net ton ,, ,,	,,	0.14	metric ton per sq. centimeter	(.1406)
	1 pound per cu. foot	,,	16.	kilos per cu. meter	(16.02) WEIGHT PER BULK.

MUNICIPAL USE AND WASTE OF WATER.

BY JOHN VENNER, CHIEF INSPECTOR, BUREAU OF WATER, SYRACUSE, N. Y.

[*Read September* 10, 1903.]

Mr. President and Gentlemen: — At almost every meeting of this Association there is a discussion of the questions of waste of water by private consumers and the stealing of water from fire services, together with suitable suggestions as to how to prevent the same. On these questions I think that all agree that the meter should be the only arbitrator.

There seems, however, to have been too little attention given to the matter of "municipal economy" in the use of water. This has led me to believe that the subject of waste in public buildings would be of interest to you.

With the rapid growth of cities the difficulty of obtaining and maintaining an adequate supply of good water becomes a very serious one. Many cities have had to go long distances for their supplies, spending large sums of money in the building and maintenance of conduits. Careless and unrestricted use of water causes these conduits to reach the limit of their capacity long before they should, and necessitates the building of new lines. It is safe to say that nearly all cities have an enormous expense in pumping considerably more water than is needed for legitimate use.

Many of the members of this Association are familiar with the water-works system of the city of Syracuse. For the benefit of those who are not, I will give a brief description of our water supply.

We obtain our water from Skaneateles Lake, about 19 miles distant from the city. This lake is a feeder of the Erie Canal, and special legislation was necessary before it could be used by the city. A vast amount of opposition was encountered, and when the state finally consented to its use by the city the size of the supply conduit was limited to 30 inches in diameter. The amount of water that this conduit will discharge is estimated to be about 14 000 000 gallons daily.

The average daily consumption is fast reaching this limit, there having been nearly 12 000 000 gallons used daily during the year

1902. This condition of affairs has made it necessary for the city to take steps to reduce the consumption by stopping all waste possible, thus prolonging the usefulness of the present conduit. This led to a study of methods by which this reduction could be accomplished.

It was in this connection that I took up the matter of public waste, commencing with the public schools.

There are thirty-four of these buildings, and all have been metered since February, 1903.

The following table shows the daily consumption of water per pupil, in gallons, based upon the average daily attendance in each school:

DAILY CONSUMPTION OF WATER PER PUPIL IN THE PUBLIC SCHOOLS OF SYRACUSE, N. Y., FOR THREE MONTHS OF 1903.

School.	Average daily attendance.	Per capita consumption, in gallons.		
		March.	April.	May.
1 Jefferson	314	17.8	21.1	24.1
2 Grant	304	22.2	25.2	24.4
3 Townsend	481	5.4	5.7	5.5
4 Garfield	434	5.1	6.6	5.2
5 Franklin	826	4.1	3.5	2.4
6 Prescott	574	9.4	9.2	6.
7 Clinton	522	16.2	15.3	14.7
8 Lincoln	414	9.1	8.	7.8
9 Vine	218	2.3	4.2	4.1
10 Frazer	428	12.8	14.2	11.
11 Genesee	412	6.	3.2	2.9
12 Commercial	86	397.	381.	497.
13 May	426	110.	114.	117.
14 Tompkins	388	5.6	6.1	8.7
15 Porter	778	4.5	4.5	3.2
16 Gere	352	33.	33.5	22.5
17 Madison	529	40.7	39.4	32.8
18 Sumner	358	20.9	20.	15.7
19 Washington Irving	439	35.3	30.9	22.6
20 Willard	81	188.8	190.9	104.4
21 Montgomery	471	5.1	4.1	4.0
22 Putnam	650	21.6	16.7	12.6
23 Andrew Jackson	353	3.5	2.9	3.9
24 Croton	605	44.5	31.2	28.
25 New High School	1 267	8.9	9.4	9.0
26 Seymour	665	26.3	23.6	23.6
27 Truant School	16	22.3	38.2	52.2
28 Delaware	523	7.5	9.2	6.6
29 Grace	259	16.8	24.3	30.9
30 Merrick	294	35.6	17.9	22.3
31 Bellevue	257	32.1	32.8	37.9
32 Danforth	348	25.9	21.4	22.
33 Elmwood	224	8.4	14.5	14.5
34 Brighton	868	5.3	4.1	3.

The wide variance in daily consumption in the different schools, ranging from 2.3 gallons to 497 gallons per pupil, shows plainly that in some there must be very large waste.

The average daily consumption in the public schools for the months of March, April, and May was about 20 gallons, or two-thirds of a barrel of water for each pupil.

The average number of gallons used daily in all of the schools for the three months mentioned was about 450 000, or 3.6 per cent. of the city's entire consumption, and represented a value, figured at the usual rates, of about $1 000 per month. The Bureau of Water receives no compensation from the city for water used for municipal purposes.

Prior to the introduction of meters in school buildings little or no effort apparently was made to prevent waste of water through defective fixtures, and such waste not only occurred during the time that schools were in session, but also was allowed to continue during vacation periods. Since the placing of the meters the water has been turned off from the buildings during all vacations. This fact makes it evident that the use of water in the schools before they were metered was even greater than the above table shows.

There is no doubt that most of the waste in schools is due to lack of proper care of plumbing and to carelessness of children in leaving water running from the faucets.

As a remedy for the first condition I would suggest that a thorough inspection of each school be made with regard to the condition of the fixtures, and to ascertain what conditions there are that might tend to increase or decrease the legitimate use of water; and that from this basis a reasonable per capita consumption for each school be arrived at. Whenever this consumption is exceeded to any large extent the school officials should be held responsible. Through the hearty coöperation of both water and school officials in this matter, I have no doubt that there could be effected a very large saving of water.

To prevent carelessness in leaving water running unnecessarily I would suggest that, wherever it is possible, all faucets in schools be required to be of the self-closing style.

These measures are to be carried out in the city of Syracuse.

The same conditions that exist in the school buildings doubtless

exist in other public buildings, and we are now engaged in placing meters on engine houses, public baths, etc.

In this paper I have not gone as deeply into this subject as I might, as I intend, at some later meeting of the Association, to give you our experience in detail, covering fully the use of water in all of our public buildings, parks, etc., as well as for watering troughs, street sprinkling, and flushing of pavements.

HISTORY AND DESCRIPTION OF THE MONTREAL WATER WORKS.

BY GEORGE JANIN, C. E., SUPERINTENDENT MONTREAL WATER WORKS.

[*Read September* 9, 1903.]

On the occasion of the convention of the New England Water Works Association in Montreal, the author thought it would be interesting to the members of the Association to give a brief history and description of the Montreal Water Works.

A few introductory words regarding the city of Montreal will not be out of place, before describing the aqueduct system.

The city of Montreal was founded in 1642, when Canada was under French domination, but it was some years before the town, on account of its industrial and commercial importance, assumed the dignities of the metropolis of the country. Montreal's attainment to this distinction is the result of its commanding geographical position on the banks of the St. Lawrence River, at the terminus of ocean navigation.

Montreal possesses a salubrious climate; it is very cold in winter according to the thermometer readings, but owing to the lack of humidity in the air, the cold is not merely tolerable but pleasant.

The area included in the limits administered by the city corporation is about 6 000 acres, containing a population of 266 466 souls, not counting any of the large suburban municipalities, which are not separated from the city by any natural boundary but really form part of the city, and which, if annexed to the city, as they soon must be, would bring the population to 350 000 souls.

The water supply of the city, with the exception of St. Denis Ward, is under the control of the municipal administration, which owns the aqueduct and imposes a rate for payment. St. Denis Ward and the suburbs are supplied from a private company, the Montreal Water and Power Company.

As for all old cities,the aqueduct of Montreal had a very modest beginning. Towards 1800 the water from springs was diverted from Mount Royal and distributed through some of the streets of the city in wooden pipes. In 1815 this precarious supply was replaced by a system of distribution of water pumped from the river and raised into tanks containing 240 000 Imperial gallons.* In 1845 the city bought this system from a private company, after which an epoch of progress was begun by the construction of a reservoir containing 3 000 000 Imperial gallons and situated at that time outside of the city at a place called "Côte à Baron." This reservoir, now abandoned, has been turned into an ornamental fountain in one of the squares of the city (St. Louis Square).

The time had now arrived when the intake from the river, in the middle of the harbor, and consequently exposed to all sorts of polutions, could no longer be used with hygienic safety to supply a city full of future promise and anxious for the health of its inhabitants. As early as 1847 it had been proposed to take water at the Lachine Rapids, above the city, and to make use of the power of these rapids to raise the water, but this scheme, and others similar, were not seriously considered until 1853, when the city council concluded to confer upon Mr. T. C. Keefer, civil engineer, the duty of preparing plans for an aqueduct capable of supplying 5 000 000 Imperial gallons daily. The study of this project, its examination by consulting engineers, etc., postponed the beginning of its construction to the year 1853, and its termination to the year 1854.

The system then established included an open canal 4¼ miles long, having its entrance about one mile above the Lachine Rapids, at an elevation of 37 feet above the level of the harbor of Montreal. The dimensions of the canal were 40 feet wide at the water surface and 8 feet deep. This canal, throughout most of its course, is actually used to supply the city at present.

At the time of its construction this canal supplied more than sufficient water to develop 300 horse power, and to raise 200 feet above the level of the water in the harbor 5 000 000 Imperial gallons of water, being at the rate of 40 Imperial gallons per capita for a population double what it was then (60 000). At the end of that canal were situated the settling basin and the wheel house,

* 1 Imperial gallon = 1.2 United States gallons (approx.).

about as they stand to-day. The hydraulic motive power was utilized by two breast wheels working six pumps to raise the water to a reservoir situated on the slope of Mount Royal along McTavish Street, forming the present low level reservoir, which is but an enlargement of the original one. That reservoir had then a capacity of 15 000 000 Imperial gallons.

The whole of this system had been well devised for the quality and quantity of water necessary for a limited future, sufficient in fact for a population double what it was then; but the rapid increase of population, which has nearly quintupled since, and the inconveniences produced by the severity of our winters on the wheels, have necessarily obliged the authorities of the water works to substitute turbines for breast wheels, and also to construct an auxiliary steam plant, with a view to replacing hydraulic power during the times of low water in summer, and during the winter on account of ice, frasil, etc. The steam plant was also found to be necessary to provide for the insufficiency of the water power, when the consumption of water by the city exceeded that for which provision had been made when the canal was constructed.

The author having mentioned a few moments ago the serious difficulties due to the severity of the winters, when ice is formed in the aqueduct and paralyzes the work of the hydraulic wheels, he believes that the best way to illustrate these difficulties would be to present to the audience a few cross-sections of said aqueduct made in 1866, during the month of March (Fig. 1). These sections show that the amount of ice formed results in a decrease in the supply of water furnished by the aqueduct, and explain the temporary incapacity of the hydraulic plant. These are the chief difficulties which have been encountered from 1856 to the present time, and it was owing to them that the authorities of the water works changed the breast wheels for turbines and made successive additions of steam pumps, until the present plant at the low level station, which will be explained further, was erected as it stands now.

Meanwhile the population of the city was increasing, and was extending itself upon the heights situated east of Mount Royal, at an altitude too great to be supplied by the system whose summit was at the McTavish Reservoir.

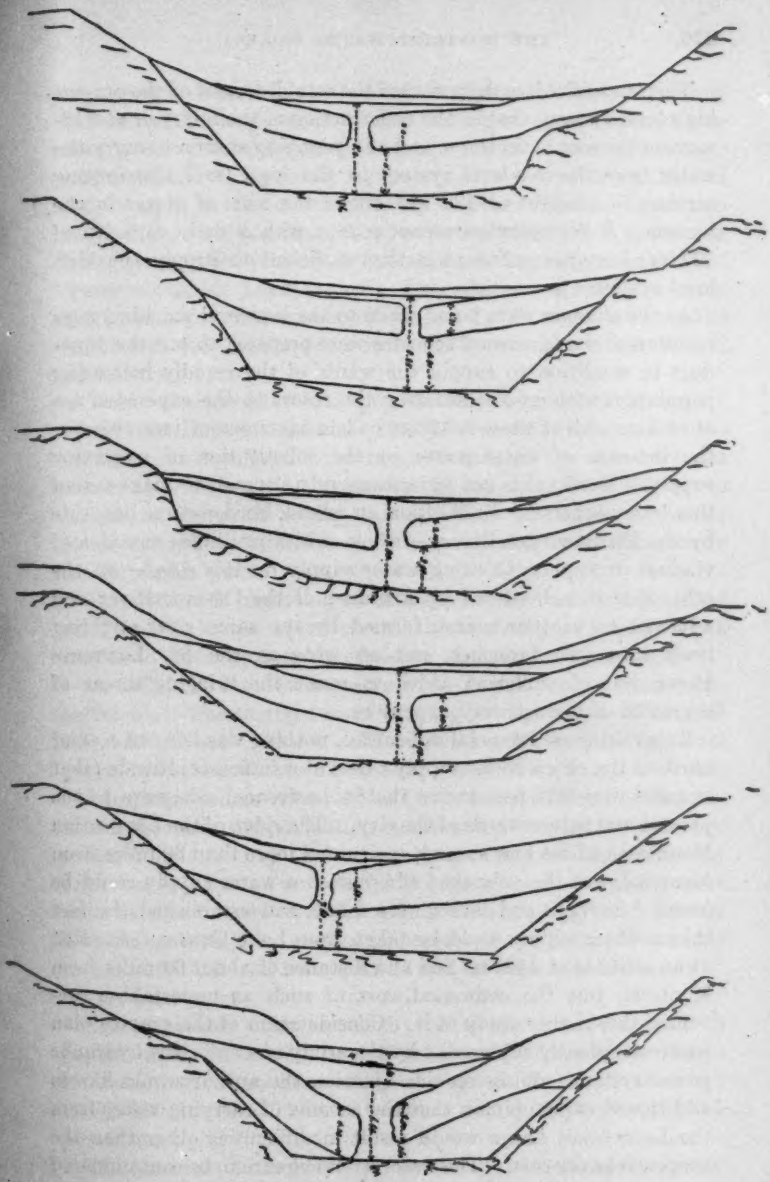


FIG. 1.—SECTIONS OF AQUEDUCT SHOWING FORMATION OF ICE.

This state of things necessitated the establishment of the present high level system, that is, the construction of the reservoir at midway on the mountain slope, and of a pumping station to carry the water from the low level system to the high level distributing service, to a height of 422 feet above the level of water in the harbor. A Worthington steam pump, with a daily capacity of 500 000 Imperial gallons, was then sufficient to supply the high level system.

As the changes were being made to the low level machinery, as mentioned above, several schemes were prepared to put the aqueduct in condition to supply the wants of the rapidly increasing population without necessitating the resort to the expensive use of steam. All of these schemes had in view one of two objects: the increase of water power or the substitution of a gravity supply. Montreal is not advantageously situated to make use of this latter scheme. Built upon an island, bordered on one side by the St. Lawrence River, — whose width precludes any idea of viaduct or syphon to bring water supply on this side, — on the other side it is bordered by a branch of the Ottawa River and adjacent to another island, formed by the same river dividing itself into two branches, not so wide as the St. Lawrence River, but of sufficient width to make the bringing across of a gravity aqueduct very expensive.

To avoid these financial difficulties, nothing was left but to find north of the city a water supply taken at a sufficient altitude (that is, more than 425 feet above the St. Lawrence), adequate to the present and future wants of the city. The ridge of the Laurentian Mountains, whose first summit is situated more than 30 miles from Montreal, was the only spot where such a water supply could be found. Surveys and levels were made, and established the fact that a water supply could be taken from Lake Ouareau, situated at an altitude of 450 feet and at a distance of about 60 miles from Montreal, but the estimated cost of such an undertaking prevented the further study of it. Consideration of the gravity plan was consequently superseded by the study of a sufficient hydraulic power system. While on this question the author would like to add that it is his opinion that the scheme of carrying water from the Laurentian Lakes would result in difficulties other than the supposed heavy cost. The water would be sure to be contaminated

in a country where the watershed supplying the lakes is entirely covered with forests, where timber cutting on a large scale is constantly going on, employing a large number of men and horses; and numbers of the creeks run nearly dry in summer and would only supply at the chosen locality impure waters. These and many other considerations were the causes which led to preference being given to the plan of the superintendent then in charge of the water works, Mr. Louis Lesage. This scheme was simply to carry the entrance of the aqueduct 3 000 feet up the river and to make it 130 feet wide at the water surface, 78 feet wide at bottom, and 14 feet deep.

These dimensions would provide sufficient power to supply 30 000 000 Imperial gallons. In 1877 the construction of works on this plan was begun, the new entrance of the aqueduct was made, and the aqueduct was dug 130 feet wide for 4 800 feet in length, as it stands to-day. The cost of the work prevented its continuation, and this accounts for the periodical growth of the steam plant.

However, this beginning of enla.gement had a favorable effect on the water in the aqueduct and the formation of ice, in such a way as to better protect the efficiency of the hydraulic pumps.

In 1878, the low level reservoir (McTavish) having become insufficient, it was enlarged so as to bring its capacity to 37 000 000 Imperial gallons. In 1889 the population fed by the high level system had increased so much that a new steam pump, of 2 500-000 Imperial gallons' capacity had to be provided for this district. This increase in the population is still going on, and the necessity of ensuring its supply against any uncertainty led the author to have the city council provide for the installation of a pump operated by electric power, which pump, of a capacity of 5 000 000 Imperial gallons, is at present in process of erection. When it is in operation the old steam plant will be kept as a duplicate in case of emergency.

The successive changes which the author has attempted to explain to his best ability have placed the Montreal Water Works in a position to provide a daily average water supply of about 24 000 000 Imperial gallons, which is sufficient for the present population.

The question of increasing the motive power will again shortly

present itself, and the competition of schemes similar to those already spoken of will be open again, together with a scheme of water filtering, because although the water taken in the river is generally wholesome, the spring-time has always a bad effect upon the waters, this being caused by the snow melting and the discharge into the river of the drainage of the lands along its banks. This inconvenience, although temporary, has led the public to wish to see a water filtering system adopted, and the municipal authorities will have to deal shortly with this question.

DESCRIPTION OF THE WATER WORKS.

Aqueduct. — As already stated, the present source of water supply for the city is the St. Lawrence River, from which the aqueduct has its entrance 1½ miles above Lachine Rapids, 38 feet above the level of water in the harbor.

The present aqueduct, from the entrance to the junction of the old aqueduct, has a mean width of 140 feet and a depth of 14 feet, for 4 800 feet; it is then continued by the old aqueduct, which has a mean width of 30 feet, a depth of 8 feet, and is 26 200 feet long. The fall is 5 inches per mile.

The aqueduct ends at a settling basin of a capacity of 1 064 885 cubic feet, used for the distribution of the motive power to the hydraulic engines and for the drawing of the water supplying the city.

At the mouth of the aqueduct a pier about 1 000 feet long has been built for the purpose of slackening the current of the river. Sluice-gates, situated at the mouth, and 2 dams with movable gates, situated in the canal, regulate the level of the water; 18 bridges cross the canal and afford the means of circulating on the roads which connect the several portions of the riverside properties.

Low level pumping station. — The water is raised by means of two systems — by hydraulic machines to the extent of about 60 per cent. of the consumption and by steam engines for the balance.

The total quantity of water raised by the pumping apparatus of that station during the last fiscal year was 8 167 734 489 Imperial gallons.

There are several buildings connected with the low level pumping station, of which these are three principal ones, — the first

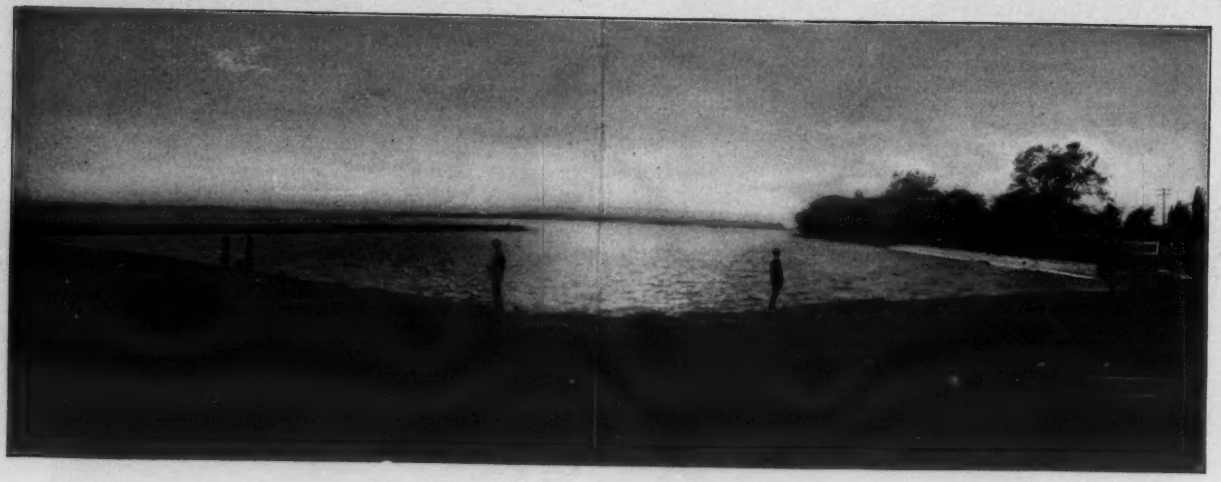


PLATE I.

STILL WATER BASIN. — ENTRANCE OF AQUEDUCT.

FIG. 1. — ENTRANCE OF AQUEDUCT, ST. LAWRENCE RIVER.

FIG. 2. — STILL WATER BASIN AT ENTRANCE OF AQUEDUCT.

FIG. 1. — NEW AQUEDUCT AT JUNCTION WITH THE OLD.

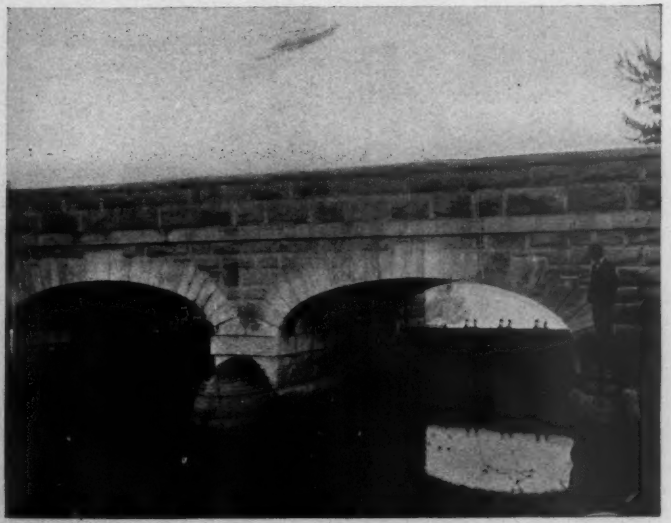


FIG. 2. — ROAD BRIDGE AT ENTRANCE OF OLD AQUEDUCT.

FIG. 1. — AQUEDUCT NEAR SETTLING BASIN.

FIG. 2. — LOW LEVEL PUMPING STATION AND SETTLING BASIN.

FIG. 1. — LOW LEVEL PUMPING STATION ENGINE HOUSE.

FIG. 2. — LOW LEVEL PUMPING STATION AND TAILRACE.

FIG. 1.—McTAVISH STREET RESERVOIR—NORTH END VIEW.

FIG. 2.—McTAVISH STREET RESERVOIR—SOUTH END VIEW.

contains the turbines, operated by the aqueduct water itself, and 4 sets of pumps, namely:

No. 1. — A Jonval turbine, with 2 double-acting pumps, which can pump 4 000 000 Imperial gallons per 24 hours.

Diameter of the wheel	8 feet.
„ „ pumps	1 foot 6 inches.
Stroke	6 feet.

No. 2. — A "Samson" horizontal double wheel, with 2 double-acting pumps and an air reservoir, which can pump 5 000-000 Imperial gallons per 24 hours.

Diameter of the wheel	40 inches.
Width „ „	20 „
Diameter of the pumps	23 „
„ „ plunger-piston	20 „
Length of stroke	36 „
Interior diameter of the air reservoir	30 „

No. 3. — A "Jonval" turbine, with 3 double-acting pumps and 2 air reservoirs, which can pump 3 000 000 Imperial gallons per 24 hours.

Diameter of the wheel	6 feet.
„ „ pump	1 foot 8 inches.
Length of stroke	4 feet.
Interior diameter of the air reservoirs	6 „ 6 inches.

No. 4. — A "Jonval" turbine, with 2 double-acting pumps and an air reservoir; capacity, 3 000 000 Imperial gallons per 24 hours.

The overflow of the settling basin and the water operating the hydraulic machines falls into a waste channel, below the building, and after a course of about 3 500 feet, flows into the St. Lawrence River, opposite the downstream point of the Nuns' Island.

The second building contains the steam-engines, comprising 3 sets of pumps, namely:

No. 1.—A high-duty Worthington engine of a capacity of 10 000-000 Imperial gallons per 24 hours.

Diameter of the high-pressure cylinder	28¾ inches.
„ „ low „ „	57½ „
„ „ plunger-piston	31½ „
Stroke	48 „
Interior diameter of the air reservoir	39¼ „

No. 2. — A high duty Worthington engine of a capacity of 10 000 000 Imperial gallons per 24 hours.

Diameter of the high-pressure cylinder	25	inches.
" " low " "	40	"
" " plunger-piston	27½	"
Stroke	38	"
Interior diameter of the feeding cylinder	35½	"
" " " air reservoir	23½	"

No. 3. — A high duty Worthington engine (duplex) of a capacity of 8 000 000 Imperial gallons per 24 hours.

Diameter of the high-pressure cylinder	33½	inches.
" " low " "	58½	"
" " pumps	37½	"
" " plunger-piston	29	"
Stroke	48	"
Interior diameter of the air reservoir	39½	"

The third building contains the steam generators, which consist of 2 batteries of 3 Heine boilers each, and a battery of 3 Lancashire boilers.

The other buildings are used as sheds for the storage of coal and supplies, machine shops, and employees' dwellings.

From the pumping station the water is forced into the low level reservoir and into the pipes through two mains of 30 inches diameter, having together a length of 16 102 feet, and through two 24-inch mains having a total length of 27 709 feet.

One of the 30-inch mains is still unfinished and only branched upon the other of the same diameter, after their passage under the Lachine Canal.

The other 30-inch main does not extend as far as the reservoir; at the intersection of McGill College Avenue and Sherbrooke Street it is connected with the two 24-inch mains, which alone go as far as the reservoir; from that point, the said 30-inch main extends on Sherbrooke Street as far as Delorimier Avenue, near the eastern limits of the city.

Low level reservoir.— The pumps at the low level station raise the water up to the main reservoir of the city, situated at the angle of McTavish Street and Carleton Road, at the altitude of 204 feet above the river and 165 feet above the intake basin of the low level pumping station.

The said reservoir, dug into the rock, has its bottom on the uneven bed of the excavation, and its perimeter walls are partly formed by the sides of the excavation, the rest of the walls being composed of undressed stone masonry pointed with cement.

It is divided into two equal parts by a masonry wall of the same character as the perimeter walls.

The capacity is 37 000 000 Imperial gallons of water.

A building attached to said reservoir contains the valves and sluice-gates regulating the distribution and the reserve of water for the section of the city supplied by the low pressure; said section comprising all that part of the city extending from the St. Lawrence River to the following limits (northwards): Sherbrooke, University, Prince-Arthur, Durocher, Pine Avenue, St. Lawrence, Duluth, Cadieux, and Mount Royal streets.

High level pumping station. — A building erected on the land adjoining the above-mentioned reservoir contains the high level pumping machines, which consist of 2 pumps operated by steam.

1. A high pressure Worthington pump (duplex) of 24 horse-power and of a capacity of 500 000 Imperial gallons per 24 hours. (This pump is almost unfit for use.)

2. A high pressure Gilbert pump (compound system) of 250 horse-power and of a capacity of 2 500 000 Imperial gallons per 24 hours.

The steam is supplied by a sectional tubular boiler of the Caldwell high pressure type, 200 horse-power, fed by 2 American mechanical stokers.

Old boilers of the locomotive type of 120 horse-power each are still used during the cleaning, or when accidents take place to the Caldwell boiler.

The pumps take the water from the low level reservoir and raise the same by a force main of 20 inches and 12 inches diameter and 1 674 feet long, passing through McTavish Street, Pine Avenue, Mt. Royal Park, and ending at the high level reservoir, situated on the slope of the mountain, opposite Peel Street, at the altitude of 434 feet above the river and 230 feet above the low level reservoir.

As above mentioned, a new 5 000 000 Imperial gallon electric pump is in course of erection at this pumping station. It will replace the very old steam plant, which will be completely overhauled and will be kept in good order in case of emergency.

High level reservoir. — This reservoir is built about in the same way as the low level reservoir. It is composed of only one compartment.

Its capacity is 1 750 000 Imperial gallons; it equalizes the water supply, and contains the reserve for the section of the city supplied by the high pressure.

The district so supplied comprises all that part of the city lying north of the limits above mentioned for the low pressure.

Distribution system. — In addition to the force mains raising the water into the reservoirs, the distribution system of the city is composed of :

28 509	feet	cast-iron	mains	of	30	inches diameter.
66 198	„	„	„		24	„ „
13 040	„	„	„		20	„ „
17 493	„	„	„		16	„ „
237 887	„	„	„		12	„ „
122 179	„	„	„		10	„ „
123 873	„	„	„		8	„ „
256 714	„	„	„		6	„ „
329 900	„	„	„		4	„ „
2 239	„	„	„		3	„ „
518	„	„	„		2	„ „
625	„	„	„		1½	„ „

Total 1 119 274 feet or 212 miles.

A map of the distribution system is shown in Fig. 2.

The distribution of water by these mains is regulated by means of 3 082 valves of various diameters.

These mains supply 1 772 public hydrants and 58 private ones.

They are all laid underground, in cut, with the exception of a portion of the 24-inch force mains, which are contained in an underground gallery for a distance of about 120 feet, from the Carleton Road crossing to the low level reservoir.

The water is distributed to the ordinary consumers by free cocks and to manufacturers, etc., by meter.

In order to complete the description of the system, I will mention the central shops and stores, situated at the corner of St. Charles Borromée and Lagauchetière streets, in the center of the city, and the secondary shops on Cadieux, Grand Trunk, and Desery streets, which provide for the wants of the service in the distant wards.

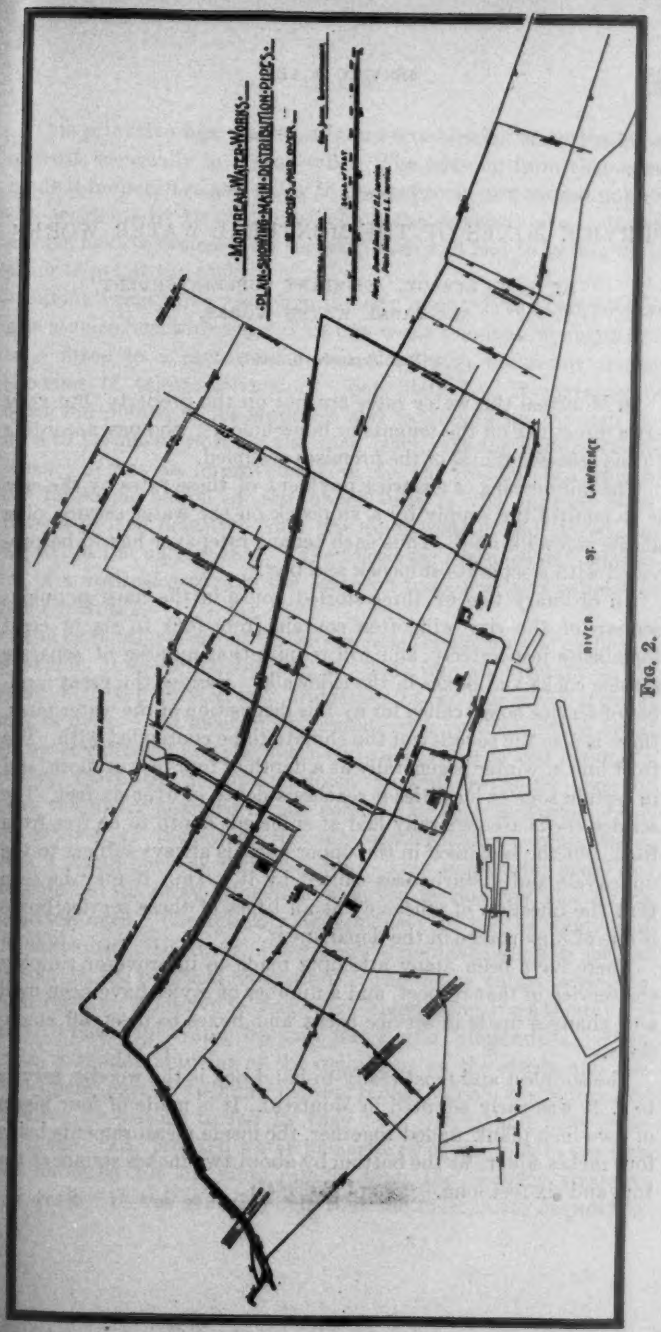

MONTREAL WATER WORKS
PLANS SHOWING MAIN DISTRIBUTION PIPES
RIVER ST. LAWRENCE

FIG. 2.

SERVICE BOXES OF THE MONTREAL WATER WORKS.

BY T. W. LESAGE, ASSISTANT SUPERINTENDENT,
MONTREAL WATER WORKS.

[*Read September* 9, 1903.]

In Montreal the water rates are not on the property, but they are a direct tax on the tenants or householders, who pay according to the assessed rental of the premises occupied.

The only means of ensuring payment of these rates by the city is to control the supply by a stopcock on the water service pipe at the sidewalk line. Thus each tenant ratepayer has to be provided with a separate stopcock and box.

An ordinary two or three-storied house in the most populous section of the city will often contain from four to six or eight tenements respectively, and will require that number of separate service cocks and boxes in the sidewalk. Besides the great number of service boxes called for by this disposition of the water rates, there is also the severity of the climate to be contended with. The frost line in winter is generally at a depth of four feet or more, and in certain soils or localities it reaches a depth of over six feet. The service cocks are generally laid at sufficient depth to be free from frost, but the box itself in the upper parts is always subject to the upheavals and disturbances caused by it. Thus it may be seen that the question of efficiency at all times of these service boxes is one of importance in the department.

There have been many attempts made to improve or simplify the service in that respect, and a number of styles have been used and changes made in service cocks and boxes to meet all conditions.

The simplest and most ready-to-hand box is the wooden service box. It was early adopted in Montreal. It is made of four pieces of two-inch plank nailed together, the inside measurements being four inches square at the bottom by about two inches square at the top, and six feet long.

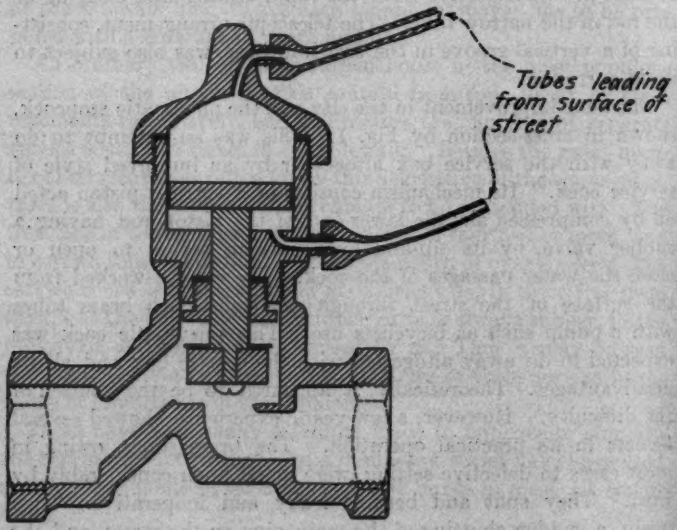
This primitive box was soon found troublesome from the effect of frost, especially in clayey soils. The heaving from this cause made it inoperative as a guide to the stopcock, and caused numerous accidents by its projecting above the sidewalk level. It was always next to useless after several years, and had to be dug up in order to get at the cock.

About twenty-five years ago the city adopted the first tubular iron service box with rod. This box was a one-inch wrought-iron tube fitted to a cast-iron bottom piece with projecting flange, allowing of telescopic action. (See Plate I.) It contained a fixed rod pinned to the stopcock and extending up through the tube to permit of working the cock from near the surface of the street. It was an improvement on the old wooden box, due to the telescopic action of the upper tube in the bottom piece. It soon proved defective from the rapid rusting and clogging of the rod in the narrow tube. The telescopic arrangement, consisting of a vertical groove in the cast-iron base, was also subject to rapid corrosion.

The next improvement in the city was the pneumatic stopcock, shown in cross-section by Fig. 1. This was an attempt to do away with the service box altogether by an improved style of service cock. Its mechanism consists of a vertical piston acted on by compressed air; the lower end of the piston rod having a rubber valve, by its up-and-down motion serves to open or close the water passages of the cock. The cock is worked from the surface of the street through one-eighth-inch brass tubes with a pump such as bicyclists use. This pneumatic cock was expected to do away altogether with the service box and all its disadvantages. Theoretically, it appeared to be the solution of the difficulty. However, a few years' experience showed several defects in its practical operation. The brass tubes, owing in most cases to defective setting, were acted upon considerably by frost. They split and became leaky and inoperative. Then again, a sudden shutting of the main pipe on the street, and the consequent partial vacuum in the pipes, caused the unusually sensitive air pistons to fall by their own weight and thus close the cocks. The crooked water passageway of the cock in use was also liable to silt up more rapidly than the ordinary straightway cock. It was generally felt that the mechanical disposition

and arrangement of the pneumatic cock, with its working tubes, required too fine setting and adjustment, and was unsuited to the rough-and-ready manipulation of the ordinary laborer.

Another tubular iron box was introduced consisting of inch and a quarter or inch and a half galvanized-iron pipe, fitting with a telescopic sleeve joint into a bottom piece made of vitrified clay. (See Plate I.) The top piece or sidewalk plate is a neat brass cap with screw threads fitted to a brass nipple on the end of the galvanized pipe. The first cost of this box is high, and its maintenance somewhat expensive. The threaded nipple and brass sidewalk caps were the chief source of trouble, as there appears to be galvanic action set up in the contact of brass and galvanized iron, which soon causes the screw threads on the iron pipe to corrode and the brass caps to fall off. Then



Montreal Water Works

—PNEUMATIC SERVICE COCK—

FIG. 1.

SERVICE BOXES, MONTREAL WATER WORKS.

PLATE I.

again the brass caps and nipples are valuable as scrap. They are easily removed and converted by the unscrupulous to the junk shop, thus requiring constant renewals by the department.

The present service box as it is being laid to-day consists of an inch and a quarter or inch and a half ordinary tarred iron pipe about 4 feet long, fitting with a telescopic service joint into a bottom piece of wood or vitrified clay, about 2 or 3 feet long. Two slits are made in the upper end of the iron pipe about 2 inches lengthwise, and the ends are turned back or splayed at right angles to form a projection to fit in the cast-iron base of the sidewalk plate. (See Plate I.) This sidewalk plate or casing is of cast-iron, cylindrical in form, about 6 inches deep by 4 inches wide. When set in the concrete of the sidewalk pavement it is perfectly rigid and the inside tube has several inches vertical play inside but cannot disturb the surface of the pavement. The service cocks are fitted with ¾-inch rods carried up to within 2 feet of the sidewalk level. The box complete, comprising rod, tube, bottom piece of wood and deep cast-iron sidewalk casing, costs about $1.90. The deep cast-iron sidewalk casing in itself weighs 23 pounds and costs 69 cents. The cast-iron removable cover is of the pattern of one long in use in the department and therefore interchangeable with the old covers in all parts of the city. Though bulky enough to be not easily lost sight of, it is not of sufficient intrinsic value as scrap iron to become an object of much trading among second-hand dealers. This box combines simplicity and cheapness and has all the advantages of more pretentious and expensive arrangements for the same purpose. It will escape the inevitable decay of time and weather in exposed situations about as long as any. It has one valued improvement by the fact that the tube or box itself can no longer be worked up by frost above the sidewalk level, thereby doing away with a fruitful source of accidents and damages against the city.

THE LAWRENCE FILTER.

BY M. F. COLLINS, SUPERINTENDENT LAWRENCE WATER WORKS.

[*Read September 10, 1903.*]

I have been requested by your President to bring before you, in a short talk about the Lawrence filter, the method of its operation and certain features of the results. Rather than bore you by a long paper, I have thought it best to show slides of the filter and its operation, and say a few words about each as it appears.

The Lawrence filter (see Fig. 1, plan of filter) was built in 1892–93 after designs and under the direction of Hiram F. Mills, C.E., member of the Massachusetts State Board of Health and citizen of Lawrence at that time. Its original cost was $65 000.00. The additions and improvements in subsequent years have raised the total cost to about $80 000.00. The filter is supplied with water from the Merrimac River by gravity, and the filter drains into an old filter gallery or brick conduit along the north side, which empties into the pump well.

The unique feature of the filter is that it has an undulating surface, divided into parts by concrete troughs, over which the water flows gradually as the filter is being filled when started in operation. This design was caused by the plan for intermittent operation, which was deemed necessary in order to thoroughly mingle air with the water for better purification. In addition, the size of the sand directly over and for five feet each side of the underdrains was finer than that in the intermediate section (size, 0.25 mm. to 0.30 mm). However, the need of intermittent filtration has not been apparent, and, as the demand for water has been constant and large, the filter has been for some time operated in a continuous manner, that is, without periods of rest each day for the purpose of allowing air to penetrate into the sand. Also, as sand has been scraped from the surface from time to time and replaced each year, it has come to pass that the distribution of sizes in different sections is no longer maintained and all of the sand is about the same size.

SCRAPING.

When it becomes necessary to scrape a section of the filter the inlet to that section is shut off the night before, and if water is not

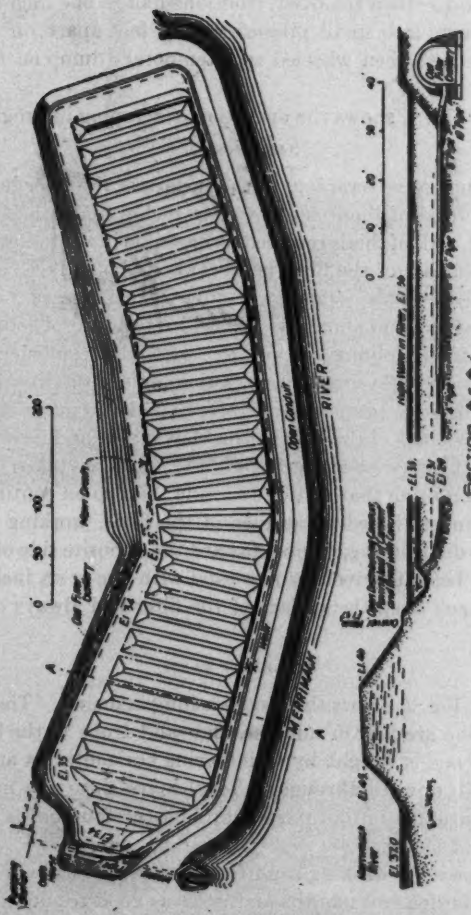


FIG. 1.—THE LAWRENCE FILTER, AS ORIGINALLY DESIGNED.

going through the sand fast enough to have the surface clear by morning, the 8-inch centrifugal pump which was put in for the purpose of draining the bed is started and the surface water pumped back into the river. Thus the section is ready to work upon at the usual time of beginning work in the morning. The

surface sand is then removed, from one-half to one inch in depth. This is thrown into small piles about ten feet apart on the surface of the bed, then wheeled to a temporary dump on the lower roadway.

Plate I, Fig. 1, shows the operation of scraping in progress.

SANDING.

In the successive scrapings of the surface of the filter bed during the year a total of about ten or twelve inches in depth of the sand is removed. All of this is replaced at one time in the following manner: The surface of the filter bed between two surface conduits is first scraped and the scrapings removed; then a section along the distributing channel about five feet wide is spaded or loosened up, and from the adjoining section, five feet wide, sufficient sand is thrown up over the first section, adjoining the distributing channel, to bring it to proper grade. New sand is then brought in to fill the lower half of the excavation thus made, and from the next adjoining five feet wide sufficient old sand is taken to cover the new and bring that section to grade, and so on continuing the operation over the whole surface of the filter, working from the line of the distributing channel toward the opposite side of the bed, the object being to cover the new sand with five or six inches of the old sand, and keep the surface of the filter bed always of the old sand.

WASHING SAND.

Plate I, Fig. 2, shows the sand-washing machine. The bowls of the machine are four in number, and sand drops to the bottom of each bowl and is caught by an inflowing horizontal jet and carried across and upward through a 3-inch pipe into the next bowl. This is continued until it passes through the four bowls and then to the sand boxes.

The process of washing sand from the lower roadway has been in operation for two months and gives as good results, both as to the amount of sand washed and the removal of river silt and organic matter, as the washing machine on the upper permanent dump.

This method does away during the summer months with the necessity of hauling the sand by teams from the lower roadway to the upper washing machine, which means a considerable saving in

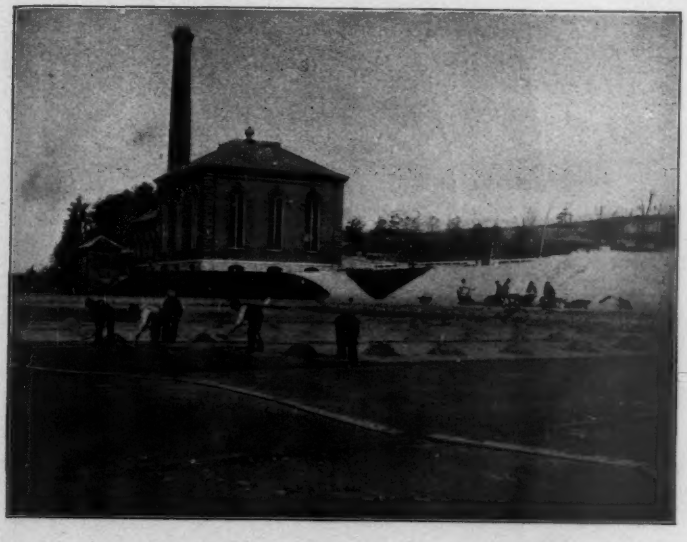


FIG. 1. — SCRAPING THE SURFACE OF THE BEDS.

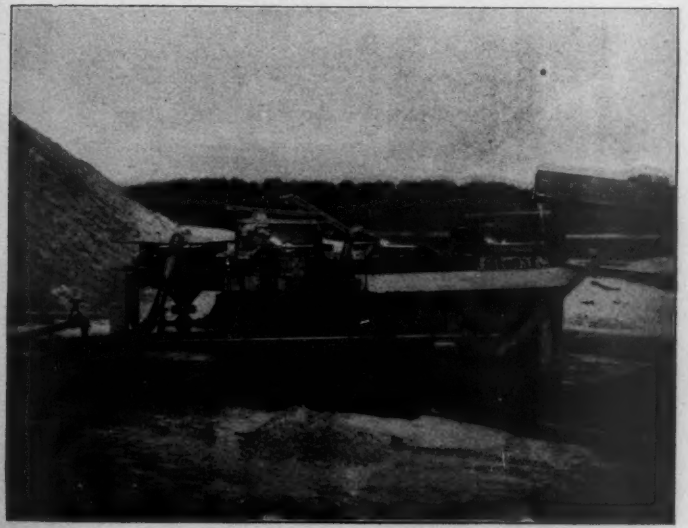


FIG. 2. — SAND WASHER.

FIG. 1. — REMOVING ICE FROM THE FILTER.

FIG. 2. — NEW ICE RUN.

team hire. Under the present system the sand is brought to the washer by a scraper with a horse attached, calling for a driver and one man to handle the scraper. Under the old method four single carts and six men were required to convey the unwashed sand to the washing apparatus.

ICE.

During the months of December, January, February, and March, scraping can seldom be accomplished without first removing ice from the surface of the filter. In order to scrape a section of the filter at such a time, the ice, together with any snow which may be upon it, must first be removed, usually on the day before scraping. In cold weather an additional coating of ice, sometimes one inch or more in thickness, forms before the filter is entirely drained, causing an increased cost and delay in scraping.

On December 1, 1901, ice on the filter was four inches in thickness, and on December 8, 1901, it was twelve and one-half inches in thickness.

Plate II, Fig. 1, shows the process of removing ice from the filter. Plate II, Fig. 2, shows an ice-run that was put in two years ago, and also the old machine in the distance. The old machine carried an 18-inch by 30-inch cake, this one carries a cake 36 inches square. It is attached to the old machine and is run by a belt. The delivery is so high that we are enabled to cut all day without moving; with the old machine it was necessary to move three or four times daily.

DIVISION WALLS.

The filter was originally built in one unit of an area of two and one-half acres, so that when any portion needed scraping it was necessary to draw the water from the entire filter and put it temporarily out of service. In 1902 the water board authorized the building of two division walls, dividing the filter into three parts. As the filter is at present, when one section is out of service, whether for the purpose of scraping or sanding, the pumps are kept running, and the only loss in addition to the lessened quantity of water filtered is a decreased duty of the pumping engine.

Plate III shows a part of the westerly section of the filter, show-

ing gate house, together with the exposed surface drainage pipe and the connection of the 30-inch main supply pipe with the old open distributing channel.

Plate IV shows the westerly division wall, with the 16-inch supply gate, also the 8-inch gate to be used for pumping from beds.

Plate V illustrates the easterly wall and gate chamber, showing water on the easterly section and the water being let on the middle section of the filter.

Plate VI is a general view of the filter as it is to-day, and shows the two walls, with the water on the easterly section, the water being let on the middle section, and the westerly section being scraped.

I know of no better description of the division walls than the following, furnished by Mr. A. D. Marble, city engineer, for the president of the water board:

"To prevent the freezing of the whole filter bed in winter while a portion was being cleaned, as well as to allow two-thirds of the bed to be in use at all times during the entire year, two walls were constructed last season across the bed, dividing the filtering area into three nearly equal parts.

"A large iron pipe ranging from 30 inches to 16 inches in diameter was laid along the river side of the bed in the old conduit and connected with the gate chamber, which supplies the bed with water from the river. This pipe feeds the different sections with the river water through 16-inch valves.

"In the old conduit is also laid an 8-inch iron pipe which is connected with a pump and assists in removing the water from the surface of the bed when preparing to clean it. This drain pipe also has valves connecting with each section of the bed.

"The concrete was mixed in the following proportions: One part of Atlas Portland cement, three parts sand, and five parts clean screened gravel. The top of the walls is at elevation 38, and on a level with the driveway and the walk around the bed. The bottom of the foundation is at elevation 30.75 (about), or about 1 foot 9 inches above the bottom of the underdrains. They were built as nearly as possible along the summit of the ridges in the bottom of the bed, and about 15 feet distant from the underdrains that convey the filtered water to the pump well. Being located so far

PLATE III.

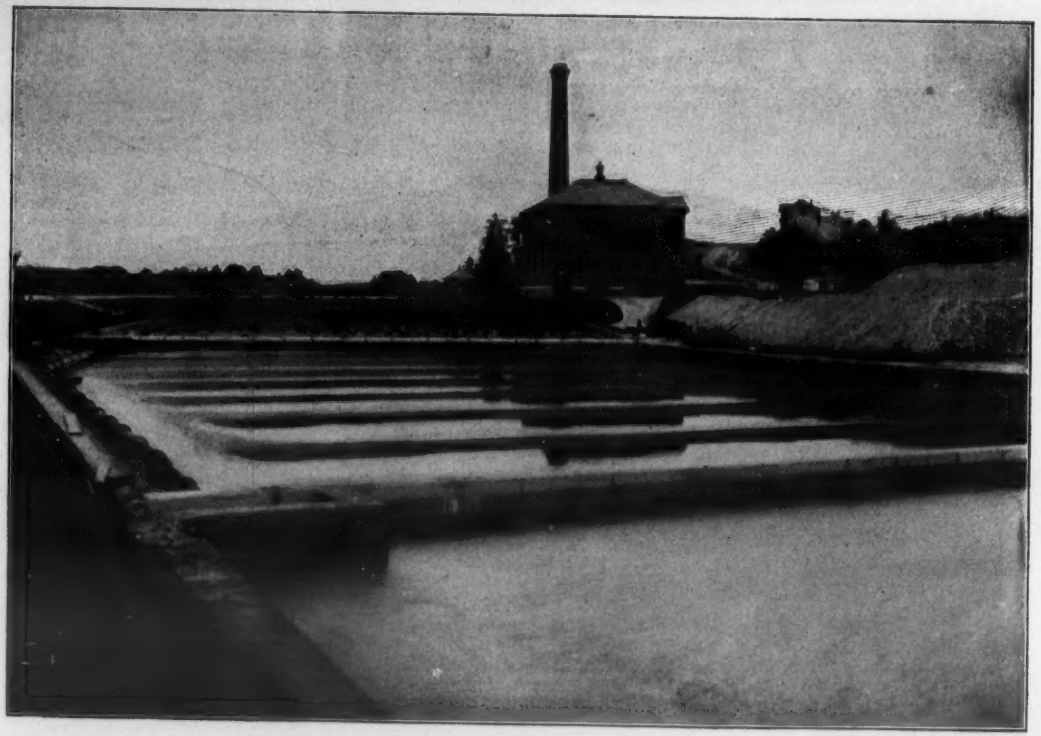
WESTERLY SECTION OF FILTER, GATE HOUSE, EXPOSED SURFACE DRAINAGE PIPE AND CONNECTION OF 30" MAIN SUPPLY PIPE WITH OPEN DISTRIBUTING CHANNEL.

PLATE IV.

WESTERLY DIVISION WALL AND GATE CHAMBERS.

PLATE V.

EASTERLY DIVISION WALL AND GATE CHAMBER.



THE LAWRENCE FILTER, WITH DIVISION WALLS.

PLATE VI.

THE LAWRENCE RESERVOIR, FROM TOP OF HIGH-SERVICE TOWER, LOOKING EAST.

PLATE VII.

from these underdrains, the danger of unfiltered water reaching the pump well from the disturbance of the bed was reduced to a minimum.

"The foundation section of the walls is of three different thicknesses, stepping up from 4 feet in thickness at the bottom to 2 feet 8 inches in thickness just below the surface of the bed. Each step in the concrete has a rise of 9 inches and a tread of 4 inches, and makes an indirect course for the water down the sides of the foundation, and gives a bond for the sand filling.

"The exposed section of the wall above the surface of the bed is 2 feet thick, capped with a pointed granite flagging 1 foot thick and of a width just equal to the thickness of the wall. The top edge of this flagging is rounded, leaving no sharp edges to be broken off in the process of cleaning the bed of ice.

"The concrete walls run into the embankment at either end sufficiently to prevent the water leaking around them from one bed into the adjoining bed.

"The valves on the feed pipe are located in small concrete chambers built close to the walls in one corner of the different sections.

"A concrete apron outside the gate chamber receives the first wash of the water in refilling the bed from the river, and prevents the surface of the bed from being disturbed.

"We anticipated that the foundations would be in river silt, and not very firm, so the plan was made for a plank foundation, but the bottom of the trench at the depth to which it was excavated was found so firm and solid that the only plank used in the foundation was a strip about 16 feet long over the filtered water conduit under the easterly wall."

RESERVOIR.

Plate VII is a view of the reservoir taken from the top of the high-service tower, looking east.

EFFICIENCY OF THE FILTER.

The following tables show the bacterial efficiency of the filter for 1901 and for the first seven months of 1903, and the typhoid fever cases and deaths for 1901 and 1902:

TABLE NO. 1. — BACTERIAL EFFICIENCY OF THE LAWRENCE FILTER.

MONTHLY AVERAGES OF DAILY BACTERIAL ANALYSES OF WATER FROM DIFFERENT PLACES IN THE LAWRENCE DISTRIBUTION SYSTEM.

(*Bacteria per cubic centimeter.*)

Month.	River at Intake of Filter.	Effluent from Filter.		Outlet of Reservoir.	Tap at City Hall.
		Bacteria.	Per c't. of Bacteria Removed by Filtration.		
1901					
January	5 600	61	98.9	38	34
February	2 500	24	99.0	21	32
March	8 900	50	99.4	22	26
April	1 400	15	98.9	16	17
May	1 400	8	99.4	12	9
June	3 000	58	98.1	49	25
July	1 800	11	99.4	8	12
August	1 600	18	98.8	11	14
September	1 800	15	99.2	12	9
October	1 900	22	98.8	7	11
November	1 300	7	99.5	7	6
December	5 300	22	99.6	24	26
*1901	3 000	26	99.1	19	18
1903					
January	12 500	58	99.5	70	71
February	7 000	33	99.5	98	75
March	4 100	20	99.5	43	38
April	2 200	12	99.5	15	19
May	4 100	18	99.6	24	24
June	18 200	14	99.9	32	45
July	3 800	18	99.5	24	27

* Average of the monthly averages.

(Figures furnished by State Board of Health.)

TABLE NO. 2. TYPHOID FEVER IN LAWRENCE.

TABLE NO. 2. TYPHOID FEVER IN LAWRENCE.

Months.	Cases.	Doubtful.	Imported.	Contracted.	* Canal Water.	** Spring Water.	** Well Water.	Total.	Deaths.	Doubtful.	Imported.	* Canal Water.	** Spring Water.	** Well Water.	Total.
1901															
January	9	. .	1	2	4	1	1	9	0	. .	. . .	. .	. .	. .	0
February	2	. .	. .	. .	1	. .	1	2	1	. .	. .	1	. .	. .	1
March	0	. .	. .	. .	. .	. .	. .	0	0	. .	. .	. .	.	. .	0
April	6	. .	2	. .	3	1	. .	6	1	. .	. .	1	. .	. .	1
May	8	. .	. .	. .	5	1	. .	8	1	. .	. .	1	. .	. .	1
June	3	. .	1	. .	. .	2	. .	3	0	. .	. .	. .	. .	. .	0
July	2	. .	. .	. .	2	. .	. .	2	1	. .	. .	1	. .	. .	1
August	12	. .	4	. .	3	4	1	12	2	. .	. .	. .	1	. .	2
September	12	. .	3	2	4	1	2	12	0	. .	. .	. .	. .	. .	0
October	17	1	3	4	5	4	. .	17	1	. .	. .	. .	. .	. .	1
November	13	1	1	2	4	1	. .	13	1	. .	. .	. .	. .	. .	1
December	16	3	2	. .	7	. .	. .	16	4	. .	. .	. .	. .	. .	4
Total, 1901	100	5	17	10	38	15	5	100	12	. .	. .	4	1	. .	12
1902															
January	8	. .	. .	. .	5	. .	. .	8	0	. .	. .	. .	. .	. .	0
February	10	. .	. .	2	6	. .	. .	10	0	. .	. .	. .	. .	. .	0
March	15	2	1	. .	10	1	. .	15	1	1	. .	. .	. .	. .	1
April	8	1	1	2	3	. .	. .	8	2	1	. .	1	. .	. .	2
May	5	1	2	. .	. .	. .	. .	5	2	. .	. .	. .	. .	. .	2
June	9	1	. .	. .	4	. .	. .	9	1	1	. .	. .	. .	. .	1
July	5	. .	. .	. .	2	. .	1	5	0	. .	. .	. .	. .	. .	0
August	3	. .	. .	. .	2	. .	. .	3	0	. .	. .	. .	. .	. .	0
September	14	1	8	. .	1	2	. .	14	3	. .	. .	1	. .	. .	3
October	4	1	1	. .	. .	1	. .	4	2	1	1	. .	. .	. .	2
November	11	1	. .	5	3	. .	. .	11	1	. .	. .	1	. .	. .	1
December	9	. .	1	1	5	. .	. .	9	0	. .	. .	. .	. .	. .	0
Total, 1902	101	8	14	10	41	4	1	101	12	4	1	3	. .	. .	12

* Canal Water. — Persons employed in mills where canal water is used and who have had access to that water.
** Spring Water and Well Water. — Persons who have used spring water or well water exclusively.

	1901	1902
Estimated population	55 000	68 500
Death-rate	1 in 5 400	1 in 5 700

DESCRIPTION OF PROPOSED NEW FILTER.

The new covered slow sand filter to be built at Lawrence, Mass., from designs of Mr. Morris Knowles, C.E., formerly a member of the Lawrence Water Board, will be located west of the present open filter, and will be separated from it by a depressed court with granolithic pavement for the washing and storing of sand.

In general design the new filter will be similar to the filters at Albany, N. Y., and Philadelphia, Pa., with concrete floor, walls, and vaulting. The filter will be 313 feet long and 103 feet wide inside, and will give a net filtering area of about ¾ of an acre.

The floor will be built in the form of inverted groined arches, 6 inches thick at the center and 15 inches thick under the piers. The concrete piers supporting the vaulting will be 15 feet center to center and will be 22 inches square down to the sand line, and from this point batter out to 2 feet 6 inches at the base.

The outside walls will be 24 inches thick at the water line, with the outside batter varying from 1 in 5 to 1 in 12, according to their position. The vaulting is to be built of concrete in the form of semi-elliptical groined arches, with a clear span of 13 feet 2 inches, rise of 2 feet 9 inches, 6 inches thick at the crown, and 21 inches thick over the piers. Ventilator openings will be provided for the admission of light and air during scraping. On top of the vaulting a layer of material 3 feet thick will be placed.

The filter will also be provided with a sand run entrance and incline to allow for going in and out of the filter for the purpose of removing or replacing sand.

The underdrain system will consist of a concrete main collector in the form of an arch above the general floor level, running the whole length of the filter, in the center bay. This collector is provided with three manholes, to permit of entrance for cleaning, if occasion demands. From this main collector the laterals start out as 12-inch terra-cotta channel pipe, laid with open joints, and after running a distance of about 15 feet reduce to 6-inch terra-cotta pipe, laid with open joints, and extend to the center of the outside bay.

The plan provides for 12 inches of gravel about the underdrains, and 4½ feet of filter sand.

In the operation of the filter the river water will be carried from

the present gate house by gravity through a 24-inch cast-iron pipe to the inlet chamber in one corner of the filter, where the flow is to be regulated by a regulating valve of special design. The water then overflows the weirs in the walls of this chamber, and is carried by open troughs down along the side walls of the filter. These troughs are provided with orifices of varying sizes, according to their position in the filter, so that the inflowing water is uniformly distributed over the whole area of the bed without disturbing the sand. The water then passes down through the sand and gravel to the laterals, and by them is carried to the main collector already mentioned.

It then passes out through a 24-inch cast-iron pipe and flows to the pump well of the present pumping station, where the flow is regulated by a float valve similar to those at Albany and Philadelphia.

PROCEEDINGS.

June Field Day.

Waltham and Newton, Mass.,
June 10, 1903.

The June meeting of the Association was held at Norumbega Park, Auburndale, Mass., on Wednesday, June 10, 1903.

Program. — Sail on Charles River, call at Waltham Pumping Station, dinner at Norumbega Park, visit to Waltham Watch Factory.

Itinerary. — Leave Boston for Waltham at 8.59 A.M. from North Station (Fitchburg Division).

Leave Waltham, Moody Street Bridge, by Charles River steamboat, at 9.30 A.M.

Arrive at Pumping Station of Waltham Water Works at 9.45 A.M.

Leave Pumping Station at 10.15 A.M.

Arrive at Norumbega Park at 10.45 A.M.

Meeting of the Executive Committee at 11 A.M.

Dinner in pavilion at 11.30 A.M.

Arrive at Watch Factory at 1.45 P.M. About two hours spent in passing through the factory.

The following were in attendance:

Members.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, G. A. P. Bucknam, M. F. Collins, W. R. Conard, F. W. Dean, H. F. Gibbs, A. S. Glover, J. O. Hall, D. A. Heffernan, H. G. Holden, J. A. Jones, E. W. Kent, Willard Kent, W. A. Kilbourn, G. A. King, C. F. Knowlton, D. A. Makepeace, W. E. Maybury, F. E. Merrill, H. A. Miller, J. W. Moran, Thomas Naylor, G. A. Sanborn, C. W. Sherman, H. O. Smith, J. E. Smith, G. A. Stacy, J. T. Stevens, W. F. Sullivan, W. H. Thomas, D. N. Tower, C. K. Walker, J. C. Whitney, W. P. Whittemore, Frank B. Wilkins, G. E. Winslow, E. T. Wiswall. — 39.

Associates.

Ashton Valve Co., by C. W. Houghton; Barr Pumping Engine Co., by H. E. Grant; Builders Iron Foundry, by Frederick N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Garlock

Packing Co., by Horace Hart; Hersey Mfg. Co., by Albert S. Glover and Walter A. Hersey; William Briggs, by Wm. Woodburn; Henry F. Jenks; Lamb & Ritchie, by H. F. Peck; Lead-Lined Iron Pipe Co., by T. E. Dwyer; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by J. C. Campbell; Ross Valve Co., by Wm. Ross; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by J. P. K. Otis; International Steam Pump Co., by Samuel Harrison. — 21.

GUESTS.

F. E. Hunter, West Newton, Mass.; L. P. Stone, Natick, Mass.; Frank P. Fisk, Milford, N. H.; F. W. Ingersoll, Engineer Pumping Station, Gloucester, Mass.; Mrs. George E. Winslow, Waltham, Mass.; Mrs. Wm. E. Maybury, Braintree, Mass.; Mrs. Samuel Harrison and Mrs. D. S. Dow, Somerville, Mass.; Mrs. Thomas Naylor, Maynard, Mass.; Mrs. Willard Kent, Narragansett Pier, R. I.; R. J. Crowley, Member Water Board, Lowell, Mass.; Miss Almira Winslow, Mrs. C. W. Houghton, J. O. Cheever, Boston, Mass.—14.

After dinner the Association was called to order by President Charles K. Walker; the Secretary read the names of the following applicants for membership, who were recommended by the Executive Committee:

For Resident Member.

Samuel C. Manley, Augusta, Me., President and General Manager Maine Water Company; W. J. Wetherbee, Leominster, Mass., Superintendent and Registrar, Leominster Water Works; M. J. Doherty, Natick, Mass., Engineer Metropolitan Water Works at Pegan Filter Beds.

For Non-Resident Member.

William Booth Bryan, London, England, Engineer-in-Chief East London Water Works Co.; George T. Ingersoll, Schenectady, N. Y., Superintendent of Water Works; J. S. Robinson, Columbia, Tenn., Superintendent of the Columbia Water & Light Co.; Robert N. Ellis, Jacksonville, Fla., Superintendent of Water Works.

On motion, the Secretary was instructed to cast one ballot in favor of the applicants, which he did, and they were thereupon declared elected.

The President announced that Mr. Henry F. Jenks had been appointed a committee to arrange for the exhibits of Associates at the Montreal Convention.

The business meeting then adjourned

EXECUTIVE COMMITTEE.

Records of Meeting of the Executive Committee of the New England Water Works Association, Friday, April 17, 1903, *at headquarters, Tremont Temple, Boston, Mass.*

Present: President Charles K. Walker, V. C. Hastings, Edwin C. Brooks, George A. Stacy, H. G. Holden, Willard Kent, L. M. Bancroft, Charles W. Sherman, Robert J. Thomas, Frank E. Merrill.

The following letter from Mr. S. E. Tinkham, Secretary of the Boston Society of Civil Engineers, with reference to the admission of the New England Association of Gas Engineers to joint occupancy of rooms in Tremont Temple, was read:

BOSTON SOCIETY OF CIVIL ENGINEERS,
715 TREMONT TEMPLE,
BOSTON, MASS., April 6, 1903.

MR. WILLARD KENT, SEC'Y N. E. W. W. ASSOCIATION,
NARRAGANSETT PIER, R. I.:

Dear Sir, — The New England Association of Gas Engineers has asked this society if arrangements can be made by which that Association can use for its headquarters the rooms now used jointly by the Water Works Association and the Engineers' Society.

The Association of Gas Engineers has a membership of about two hundred men connected with the various gas companies in the New England states. At present it holds one meeting or convention each year at some hotel in Boston, but it is the hope of its officers that by having a place in Boston where its members can drop in when they have a few minutes to spare and examine the periodicals on our tables, the usefulness of the society and the interest of its members may be increased.

The Board of Government of the Engineers' Society have assured the directors of the Gas Association that they viewed with favor any movement tending towards a common headquarters of the several engineering organizations located in Boston, but inasmuch as the rooms were used jointly with the Water Works Association, no definite answer could be given until after consultation with that Association.

In order that the matter may be fully and carefully considered, the Engineers' Society has appointed a committee of three from its Board of Government, who are authorized to represent that society and to act definitely in the matter.

If your Executive Committee look favorably upon this bringing together of organizations having similar objects, it is suggested that a committee from its members be appointed to confer with our committee and see if some arrangement cannot be made beneficial to all interested.

Very truly yours,
S. E. TINKHAM, *Secretary.*

and after due consideration and a general discussion, Willard Kent, Charles W. Sherman, and L. M. Bancroft were, on motion of Robert J. Thomas, elected a committee with power to act, to confer with the committee from the Board of Government of the Boston Society of Civil Engineers, to consider the question of increase of salary of the assistant secretary and to make such definite arrangements as might be deemed advisable in the premises.

Messrs. Horace G. Holden and Frank E. Merrill of the committee on June and September meetings reported at length with relation to the same, and on request of the committee and by

direction of President Charles K. Walker, Mr. J. O. A. LaForest, of Montreal, was made an additional member of the committee on the September convention.

No further business appearing, the meeting was adjourned without day.

Attest:

WILLARD KENT, *Secretary.*

Records of Meeting of the Executive Committee of the New England Water Works Association held at Norumbega Park, Auburndale, June 10, 1903.

Present: President Charles K. Walker, E. W. Kent, George A. Stacy, H. G. Holden, Willard Kent, L. M. Bancroft, Charles W. Sherman.

The following applications were considered and the applicants recommended for membership in the Association: Samuel C. Manley, Augusta, Me.; W. J. Wetherbee, Leominster, Mass.; M. J. Doherty, Natick, Mass.; Wm. Booth Bryan, Clapton, London; George T. Ingersoll, Schenectady, N. Y.; J. S. Robinson, Columbia, Tenn.; and Robert N. Ellis, Jacksonville, Florida.

Attest:

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association was held on August 13, 1903.

Present: President Charles K. Walker, V. C. Hastings, E. C. Brooks, C. W. Sherman, L. M. Bancroft, R. J. Thomas, G. A. Stacy, and Willard Kent.

The following applications are considered and the applicants recommended for membership in the Association: C. Dwight Sharpe, of Putnam Conn.; Tyler H. Bird, of Belfast, Me.; George S. Brown, of Danielson, Conn.; Bernon E. Helme, of Kingston, R. I.; Phil S. Smith, of Montpelier, Vt.; Thomas William Lesage, Montreal, Canada; S. A. Stearns, Granite, Ill.; George Janin, Montreal, Canada; and Jos. D. Pointer, of Palatka, Fla.

On recommendation of Mr. Sherman the following amendment to the Constitution is approved by the Executive Committee, and it is voted that the proposed amendment be presented to the Association for action at the September Convention:

PROPOSED AMENDMENT TO CONSTITUTION, ARTICLE IV.

Strike out from Section 2 the following:

"which shall include a subscription to the Journal of the New England Water Works Association."

Add a new section as follows:

"SECTION 4. Three dollars of the dues of each member or associate, or such portion thereof as may be required, shall annually be applied to payment of a subscription to the Journal of the New England Water Works Association."

The report of the sub-committee, consisting of Messrs. Sherman, Bancroft, and Kent, on the sub-lease of Association headquarters and salary of assistant secretary, is made as follows: That the following agreement has been made with the Boston Society of Civil Engineers:

Memorandum of an agreement made April 30, 1903, *by a committee representing the Executive Committee of the New England Water Works Association and a committee representing the Board of Government of the Boston Society of Civil Engineers.*

First. That authority be given to the New England Association of Gas Engineers to use the rooms now occupied jointly by the two societies and to place upon the shelves such books as the Gas Association desire.

Second. That the price of this use of the rooms to be paid by the Gas Association be fixed at one hundred dollars ($100) for one year.

Third. That the income from this rental constitute an Improvement Fund for the improvement of the rooms and furniture, to be expended with the approval of the secretaries of the two societies.

WILLARD KENT,	E. W. HOWE,
CHARLES W. SHERMAN,	S. E. TINKHAM,
LEWIS M. BANCROFT,	F. P. MCKIBBEN,
Committee of the New England Water Works Association.	*Committee of the Boston Society of Civil Engineers.*

and that the salary of the assistant secretary has been made $35 per month.

Whereupon it is voted that the report of the sub-committee be accepted and their action approved.

Voted: That William Lyman Underwood be invited to address the Association at Montreal on the subject of "Mosquitoes, and Suggestions for their Extermination," and that his expenses in connection therewith be borne by the Association.

Adjourned.

WILLARD KENT, *Secretary.*

OBITUARY.

CHARLES F. PARKS, who was elected a member of the Association on December 11, 1889, died on April 21, 1903.

He was born April 10, 1850, and was educated as a civil engineer at the Massachusetts Institute of Technology. After leaving the Institute he began practice in general engineering work at Waltham, Mass., and later became engineer for the town. In 1885 he formed a partnership with Mr. William Wheeler under the firm name of Wheeler & Parks; the firm built the water works at Belfast, Me.; Exeter and Derry, N. H.; Putnam, Danielson, Portland, Stonington, and Mystic, Conn.; Braintree and Cottage City, Mass.; Palatka, Fla.; Paris and Winchester, Ky.; and also reconstructed the works at Ashland, Wis., and Knoxville, Tenn. The partnership was dissolved in 1894. Mr. Parks subsequently built the water works at Pittsfield, Me., but thereafter until the time of his death he devoted the greater part of his time to his private interests and to the care of his health.

JAMES M. GALE, for forty years chief engineer of the water department of Glasgow, Scotland, died September 7, 1903. He was born in Ayr in 1830, and at the age of fourteen he joined the engineering staff of an elder brother, William Gale, then engineer for the Gorbals Water Company, with whom he remained until 1855. During this time he attended the famous engineering lectures of Professor Rankine and the mathematical lectures of Professor Laing. In 1855 he was appointed resident engineer on the city section of the Glasgow water works, then being constructed under J. F. Bateman, and on their completion in 1859 he was appointed chief engineer. From that time until 1902 he was in continuous charge of the works. Under his direction the waste of water was curtailed and many important new works built, including a second aqueduct from Loch Katrine.

Mr. Gale was elected an Honorary Member of the New England Water Works Association on January 16, 1889.